

A TEXT-BOOK

OF

PATHOLOGICAL ANATOMY

AND

PATHOGENESIS.



A TEXT-BOOK

OF

PATHOLOGICAL ANATOMY

AND

PATHOGENESIS

BY

ERNST ZIEGLER

PROFESSOR OF PATHOLOGICAL ANATOMY IN THE
UNIVERSITY OF TÜBINGEN

TRANSLATED AND EDITED FOR ENGLISH STUDENTS

BY

DONALD MACALISTER M.A. M.D.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, FELLOW AND MEDICAL LECTURER
OF ST JOHN'S COLLEGE, UNIVERSITY LECTURER IN MEDICINE, AND PHYSICIAN
TO ADDENBROOKE'S HOSPITAL, CAMBRIDGE.

PART II—SPECIAL PATHOLOGICAL ANATOMY

SECTIONS IX—XII

London:

MACMILLAN AND CO.

AND NEW YORK

1886

Cambridge:
PRINTED BY C. J. CLAY, M.A. AND SONS,
AT THE UNIVERSITY PRESS.

PREFACE

When the second volume of this work appeared in 1884 I expressed the hope that the third and concluding volume would be ready in the following year. Owing in part to my increased academical duties, and in part to the unexpected demand for new editions of the volumes already published, I have been unable until now to find time for the fulfilment of my task. To the many readers in all parts of the world who have sent me friendly enquiries on the subject, I must here express my regret at the unforeseen delay. In some respects at least the work has not suffered thereby, for I have been enabled to profit in some measure by the valuable improvements which Professor Ziegler has made in the fourth German edition, and to bring up to date the references to some of the rapidly advancing parts of the subject. The indexes of authors and of subjects appended to the volume have been made with much care, and refer to the entire work.

It should be stated that the author, in order to give completeness to the text-book for German students, has with the help of his colleagues Dr Haab and Dr Wagenhäuser prepared an additional volume on the pathological anatomy of the Eye, Ear, Bones, Muscles, and Genital Organs—on what in fact is generally described as surgical

pathology. After consultation with several teachers of experience I have decided to adhere to the plan indicated in the second volume, and to leave these additional sections alone, at least for the present. They are not wholly Professor Ziegler's, and their subject-matter is perhaps more likely to be studied profitably in special text-books.

To the acknowledgements already made I have to add my sincere thanks to Dr James Ross, who has read for me the pages on the Nervous System. His general approval of them gives me reason to hope that in this difficult part of the work I have not fallen into any serious error.

DONALD MACALISTER

ST JOHN'S COLLEGE, CAMBRIDGE,
October 1886.

CONTENTS

SECTION IX.

THE URINARY ORGANS.

SECTION X.

THE RESPIRATORY ORGANS.

SECTION XI.

THE CENTRAL NERVOUS SYSTEM.

SECTION XII.

PERIPHERAL NERVOUS SYSTEM.

INDEX OF FIGURES

SECTION IX.

THE URINARY ORGANS.

CHAPTER LXIV.

MALFORMATIONS OF THE URINARY ORGANS.

516. **The urinary organs** include the kidneys, the ureters, the bladder, and the urethra. The kidney is the secreting organ, by which water and a number of other substances are separated from the blood. The other organs named serve merely to convey the urinary secretion out of the body.

The development of the urinary organs is subject to certain abnormalities, but they are seldom such as to imperil life by preventing or seriously hindering the secretion and removal of the urine. The consequent malformations consist chiefly of deviations from the normal form, position, or number of particular parts: anomalies in the minute structure of the kidney are much more rare. Such anomalies however are of great importance, inasmuch as they may prove the starting-point for tumours of great size.

The post-embryonic disorders of the urinary apparatus affect either the kidney or some part of the urinary tract. Many of them continue to affect the part only in which they arise, while others extend by continuity to contiguous parts of the tract and in some cases ultimately affect the whole apparatus.

Most urinary disorders are haematogenous, *i.e.* traceable to some disorder of the blood; and of all the urinary organs the kidney is most liable to be affected. Disease of the kidney or of the internal parts of the urinary channels is much less frequently the result of injurious agencies reaching them from the urethra. A third and not unimportant group of affections arise from the extension to the urinary organs of morbid processes affecting adjacent parts.

Development of the urinary organs. In man the urinary organs are derived from two distinct groups of structures which may be described respectively as embryonic and permanent (KÖLLIKER), or primary and secondary. The primary structures are the primordial kidneys or wolffian bodies, and the wolffian ducts.

The **wolffian duct** on each side arises from a columnar mass of cells (the intermediate cell-mass) lying between the lateral mass of the mesoblast and the anterior part of the protovertebral column. This mass presently becomes hollowed out into a duct opening posteriorly into that part (urogenital cloaca)

of the stalk of the allantois which lies within the body of the embryo, and which ultimately becomes the urinary bladder and the urachus.

The **wolffian body** arises independently of the wolffian duct from another part of the intermediate cell-mass. The mass breaks up into a number of transverse cords of cells appearing at first to be connected with the peritoneal epithelium. These cords speedily become excavated into caecal tubules (wolffian tubes), which are more or less convoluted and ultimately open into the wolffian duct. The organ thus developed is not unlike the permanent kidney.

The secondary or **permanent kidney** and the ureter are later developments. The ureter arises as a dorsal diverticulum from the hind-end of the wolffian duct near its opening, the diverticulum growing forwards on the dorsal side of the wolffian body. The kidney is developed from the hindmost part of the intermediate cell-mass, the part namely that did not break up into wolffian tubes. The cells of the mass apply themselves to the growing ureter, and become excavated into tubules; collecting tubes spring simultaneously from the ureter, and becoming continuous with the former give rise to typical renal tubules. The **ureter** does not long remain attached to the wolffian duct, its opening being gradually carried back until it enters the cloaca independently. The renal tubules in the cell-mass become convoluted and round their caecal ends appear small aggregations of cells, in which blood-vessels develope forming the vascular **glomeruli.** These glomeruli then push in or invaginate the renal tubules, and presently a series of spherical structures is produced, each consisting of a coil of convoluted blood-vessels almost entirely surrounded by a double envelope continuous with the wall of a renal tubule. The stalk or pedicle of the glomerulus passes out at the point where the original invagination took place, which is usually opposite to the starting-point of the tubule. This spherical structure so formed is the **malpighian body**, the spherical envelope being the **capsule** of Bowman. Meanwhile the tubules become elongated and convoluted, and are soon differentiated into the various segments recognised in the adult kidney.

In the human foetus of eight weeks the kidney is already a lobulated organ with a number of completely-formed malpighian bodies. The papillae (Art. 520) are apparent at the end of the third month, and some of the tubules have attained their permanent form by the fourth month. Glomeruli continue to be formed throughout the whole time of foetal life and for some time after birth. The lobulated external form usually disappears during the first year of infancy.

The **bladder** is derived from the primitive urachus or stalk of the allantois, which arises in the first month from the hind-gut as a caecal diverticulum lined with hypoblast. The urachus thus opens primarily into the terminal portion of the gut and afterwards becomes separable into two segments, the posterior forming the urogenital sinus or cloaca, the anterior being dilated into the bladder and receiving the ureters. In the second month the bladder appears as a spindle-shaped cavity communicating below with the anal portion of the gut and above through the still patent urachus with the umbilical cord. At a later stage the urachus contracts and ultimately closes into a solid cord—the median ligament of the bladder. The closure is not in all cases complete (LUSCHKA, *Virch. Arch.* vol. 23); even in adults it may persist as a fine tube communicating with the bladder and lined with epithelium.

References on the development of the urinary organs:—BALFOUR, *Comp. Embryology* II ch. 23 London 1881 (with bibliography); KÖLLIKER, *Entwickelungsgeschichte* Leipzig 1879; FURBRINGER, *Morphol. Jahrbuch* IV 1878; SEMPER, *Arbeiten a. d. zool. Inst.* II, III Würzburg 1875—76; SPENGEL, *ibidem* III; BRAUN, *ibidem* IV; KUPFFER, *Arch. f. mikr. Anat.* I, II (1865—66); KOWALEWSKY, *Die Bildung d. Urogenitalanlage b. Hühnchenembryonen* Warsaw 1875; SEDGWICK, *Quart. J. Micro. Sci.* XXI 1880—81; ALLEN THOMSON, *Quain's Anatomy* II London 1882 (with full references).

517. Total **absence of the kidneys** occurs only in gravely malformed foetuses, and is of course incompatible with independent life.

Absence of one kidney is rare in foetuses otherwise well-developed. It does not interfere with growth and development, inasmuch as the other kidney becomes hypertrophied and assumes the whole work of excretion. The left kidney is more often wanting than the right. The corresponding suprarenal and ureter are usually absent, though in some instances rudiments of the lower extremity of the ureter have been found.

Congenital atrophy of one kidney is more common than entire absence. In well-marked cases the atrophied kidney appears as a thin plate of fibrous tissue 2—5 cm. in length and 1·5—3 cm. broad, with few or no traces of tubules or glomeruli, and supplied by renal vessels normal in position but abnormally small. Where the atrophy is less marked the remnants of renal tissue are more abundant.

The causes which determine the non-development of one of the kidneys are unknown. We can only say that for some reason the outgrowth from the primitive ureter out of which the kidney is fashioned has been hindered or altogether suppressed. Atrophy of the kidney must often originate in some similar condition of whose precise nature we are equally ignorant. In some cases however traces of inflammation, in the form of cellular infiltration and fibrous hyperplasia, are discoverable in the rudimentary organ. We are thus led to infer that intra-uterine inflammation of the kidney is possible and may lead to arrest of its development.

Among congenital **anomalies of form** the persistence of the foetal lobulations is the most common. The boundaries of the renal segments are usually indicated by shallow furrows; it is very uncommon to find the furrows so deep that the segments are entirely separated into distinct *renculi*.

Cohesion of the two kidneys most frequently takes the form of the so-called '**horse-shoe kidney**,' in which the organs are found closer to each other than is normal and their lower ends are united by a band either of fibrous tissue or of ordinary renal tissue. Cohesion of the upper or middle parts is very much rarer. When the kidneys coalesce entirely into one there is usually very considerable misplacement of the organ. It is often seated just above the promontory of the sacrum in the form of a thick cake or disc, from the anterior aspect of which arises a single or double pelvis with from one to four short ureters. In a few cases the united kidneys have been found on one or other side of the spinal column.

The renal vessels of the united kidneys are always abnormal in their origin and are frequently multiple. Thus when the organ is just above the sacrum the arteries spring from the lower part of

the aorta near its bifurcation, or from one of the common iliacs, while the veins enter the corresponding parts of the vena cava or iliac veins.

This abnormal cohesion and the malposition of the kidneys indicate that the primitive ureters or the corresponding cell-masses were checked in their growth forwards and came early into contact.

A normal or malformed single kidney, like the horse-shoe kidney, may be misplaced during development; this condition is referred to as **dystopia.** It occurs most frequently in the case of the left kidney, which approaches the middle line in the neighbourhood of the sacrum. The renal vessels are abnormal in their origin and the ureter is shortened, but the corresponding supra-renal usually occupies its normal position in the abdomen.

The kidneys may in like manner be displaced after birth. The right is most often displaced: the cause is to be sought partly in some outward mechanical violence, partly in a loose or extensible condition of the perinephral structures, and especially of the peritoneum. The origin of the renal vessels in such cases is not necessarily abnormal, and the ureter is not abnormally short, though it may be twisted or otherwise disturbed. The kidney is moreover in general readily movable. When the mobility is due to the presence of a mesonephron, or peritoneal fold loosely attaching the kidney to the spine, the case is described as one of **floating kidney.** It is more common in women than in men, and on the right side than on the left. On congenital renal cysts and tumours see Arts. 551 and 556.

References :—RAYER, *Maladies d. reins* III Paris 1839 ; HARE, *Med. Times and Gaz.* 1, 1858 and 1, 1860 ; ROLLET, *Die bewegliche Niere* Erlangen 1866 ; KLEBS, *Handb. d. path. Anat.* I 1870 ; ROSENSTEIN, *Virch. Arch.* vol. 53 ; PERL, *ibid.* vol. 56 (with references) ; GRUBER, *ibid.* vols. 33, 68 ; BEUMER, *ibid.* vol. 72 ; SAWYER, *Floating kidney, Birmingham Med. Rev.* 1872 ; WOLFLER, *Wien. med. Wochenschrift* 1876 ; Report, *Trans. Path. Soc.* XXVII (1876) ; EBSTEIN, *Ziemssen's Cyclopaedia* XV (1877) ; HERTZ, *Virch. Arch.* vol. 46 ; LANDAU, *Die Wanderniere d. Frauen* Berlin 1882, trans. by CHAMPNEYS (New Syd. Soc.) London 1884 ; NEWMAN, *Glasgow Med. Journal* August 1883 (with full bibliography); W. ROBERTS, *Urinary and renal diseases* London 1885.

518. **Malformations of the ureter** and pelvis of the kidney are met with both in normal and in malformed kidneys (Art. 517).

The commonest variety is the duplication on one or both sides of the pelvis and first part of the ureter. It is very rare for the pelvis to be further subdivided into a larger number of tube-like calices.

The duplication seldom extends throughout the whole length of the ureter so that the tubes open separately into the bladder. They usually run side by side, though cases are on record in which they appeared to cross each other.

Partial duplication of the ureter implies an early subdivision of the primitive diverticulum (Art. 516); complete duplication must be due to the simultaneous development of two diverticula from the wolffian duct.

Both normal and abnormal ureters may open in abnormal situations. In the male one ureter may open into the colliculus seminalis or into a seminal vesicle, in the female into the urethra, vagina, or uterus. A secondary coalescence of one ureter with the müllerian duct is sometimes observed.

In rare instances valvular folds of mucous membrane and twists or kinks in the tube may so obstruct the outflow of urine as to give rise to hydronephrosis (Art. 552).

Congenital atresia of a ureter or pelvis, or of a single calix, is rare.

References:—KLEBS, *loc. cit.*; HELLER, *Deut. Arch. f. klin. Med.* V; WEIGERT, *Virch. Arch.* vol. 70; HOFFMANN, *Arch. d. Heilk.* XIII; BOSTRÖM, *Beitr. z. path. Anat. d. Niere* Freiburg 1884.

519. Of the **malformations of the bladder** the most serious is extroversion (otherwise *fissura, ecstrophia,* or *inversio vesicae*).

As was pointed out in Art. 9 this malformation is due to the imperfect closure of the abdominal walls and of the bladder: a defect remains above the symphysis through which the posterior wall of the bladder protrudes. The symphysis in many cases remains likewise unclosed, while the penis is rudimentary and the urethra opens on its upper surface (epispadias).

More rarely the bladder itself is closed and protrudes through the abdominal fissure or through the umbilicus (*ectopia vesicae*). Sometimes the anterior wall is closed while the posterior remains open, a communication existing between the bladder and the pelvic cavity or the vagina.

Very frequently we find remains of the urachus in the round or median ligament of the bladder. They take the form of a narrow patent channel or of small detached cysts, which may be either closed or open toward the bladder. In the latter case they sometimes become distended with urine when the bladder is overfilled. If any impediment to the normal outflow of urine take place in infancy, the urachus may never close at all; and occasionally it has been known to serve as a means of emptying the bladder.

Division of the bladder into two separate or partly separate portions (*vesica bipartita* or *bilocularis*) is very rare: the two cavities may lie side by side or one above the other.

Congenital diverticula of the bladder are very rare.

Atresia of the vesical orifice of the urethra or of a ureter is also rare: in the former case, as we have said, the urachus remains patent.

Absence of the bladder unaccompanied by any other grave malformation is seldom observed; but it is more frequently found to be abnormally small. When the bladder is absent the ureters open into the urethra.

Absence of the urethra occurs in both sexes: in females the bladder may open directly into the vagina.

Atresia of the urethra also occurs in both sexes, and is due either to defect of some part of the canal or to obliteration of its orifice.

The canal may be abnormally narrow either throughout or at some particular part (congenital stricture). The contraction is in some cases due to hypertrophy of the colliculus seminalis.

When the urethra opens on the upper aspect of the penis the condition is called **epispadias**, when it opens on the under aspect **hypospadias**. The latter is the more common: the orifice may be either in the penile portion, or in the anterior and even in the posterior attachment of the scrotum (*hypospadias perineoscrotalis*). The penis is usually small and stunted.

Occasionally we meet with cases in which the urethra has more than one external orifice: and in males the glans penis is sometimes pierced with what appears to be a second meatus, but is in reality a short passage ending caecally.

CHAPTER LXV.

CLASSIFICATION OF RENAL DISORDERS.

520. **Structure of the kidney.** The kidney is a compound tubular gland by which water, certain salts, and nitrogenous waste-products are separated from the blood and excreted. Abnormal substances which have gained access to the blood are likewise in great measure removed from the body by this channel. The peculiar structure of the kidney corresponds with its function of separating these substances from the blood which circulates through it.

On section the kidney is seen to consist of two well-marked zones, the cortex without, the medulla within. The **cortex** forms a stratum from 8 to 10 mm. in thickness, enclosing the **medulla** which has the form of a number of rounded cones projecting inwardly, the free apices being known as **papillae**.

These medullary cones or malpighian pyramids are made up chiefly of tubules and blood-vessels, whose general course is from the base to the apex. The number of tubules increases as we approach the base of a pyramid, partly because they subdivide, partly from the presence of tubules passing for a short distance into the pyramid from the cortex and then doubling back towards the cortex again. The latter tubules are slender and narrow, especially in the recurrent part; they are described as **Henle's loops**. The branching tubules are considerably wider and are known as the **collecting tubes**. The blood-vessels and the tubules are bound together by a small quantity of connective tissue containing lymphatic vessels.

The cortex is in the main made up of two distinct structural elements. The simpler structures are the so-called **medullary rays**. These are slightly conical portions passing up from the medulla and ceasing to be distinguishable only at the outer border of the cortex (Fig. 201 *B*): they are simply prolongations of the medullary substance and consist of like bundles of straight tubules (*k*). The vessels (*e*) of these rays are arranged in much the same manner as those of the medulla.

The tissue lying between the medullary rays is the true cortical substance or **labyrinth** (*A*), and consists essentially of a mass of tubules (*i*) of various sizes, together with blood-vessels whose peculiar course and configuration (*a b c d e f g h*) give the

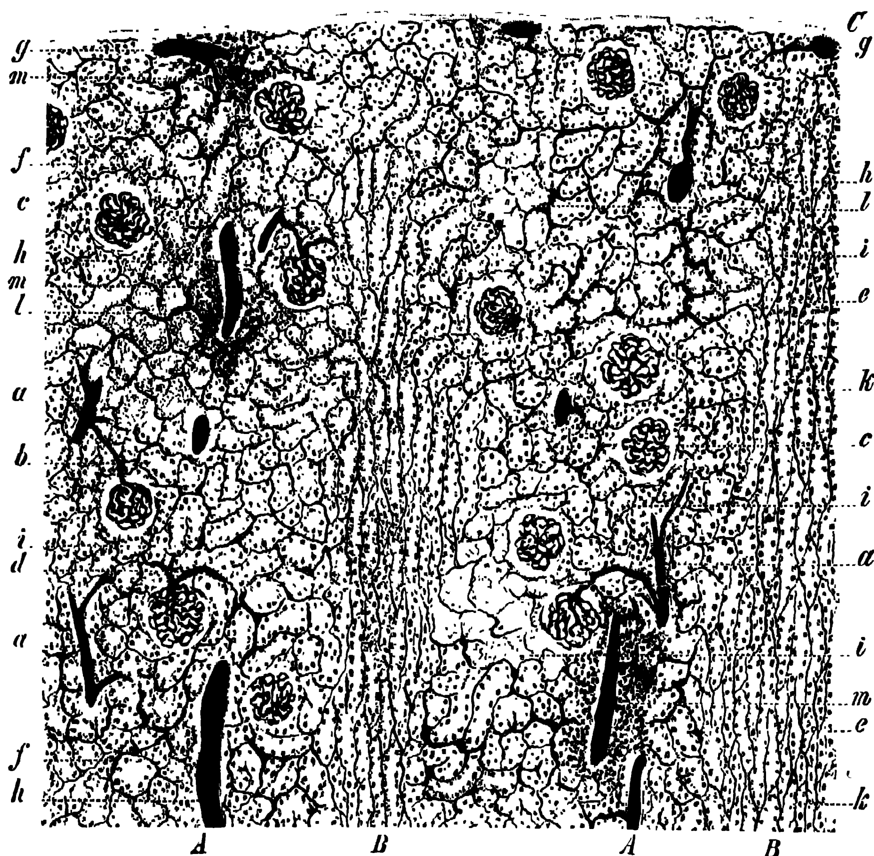


FIG. 201. SECTION THROUGH THE OUTER HALF OF THE CORTEX OF A KIDNEY AFFECTED BY RECENT INTERSTITIAL NEPHRITIS.

(*Arteries injected with gelatine and Prussian blue; section stained with alum-carmine and mounted in Canada balsam:* ×32)

A labyrinth
a interlobular artery
b vas afferens
c glomerulus
d vas efferens
e capillaries of the medullary ray

B medullary ray
f capillaries of the labyrinth
g stellate veins
h interlobular vein
i convoluted tubules
k straight tubules with Henle's loops and collecting tubes

C capsule
l degenerated convoluted tubules
m cellular infiltration round the interlobular veins

kidney its characteristic microscopic appearance. The tubules and vessels are bound together by a scanty connective tissue.

The blood which reaches the kidney enters it by the branches of the renal artery at the boundary zone between the cortex and the medulla. The greater part of it passes thence through the interlobular arteries (*a*) which run in a zigzag course through the labyrinth towards the outer surface of the organ, and then by the vasa afferentia (*b*) to the glomeruli (*c*). Only a small part of the blood passes at once into the medullary substance, and even this usually traverses a glomerulus. There are however certain very minute arterial twigs which pass directly into the medulla.

Within the **glomerulus** (*c*) the **vas afferens** breaks up into a multitude of anastomosing capillary loops, which presently reunite into a single vessel (*d*), the **vas efferens**. This leaves the glomerulus side by side with the afferent vessel, passes into the medullary ray, and there once more breaks up into a system of capillaries (*e*). This system (sometimes called the 'portal' system of the kidney) is continuous with the capillary system of the labyrinth (*f*), and this again delivers its blood into venules, which beginning beneath the capsule as **stellate veins** (*g*) pass through the labyrinth as **interlobular veins** (*h*) to the inner border of the cortex.

The course of a urinary tubule commences at the hollow sphere or **capsule** of Bowman which surrounds the glomerulus. At the pole opposite that through which the vessels enter, the cavity of the capsule opens by a somewhat narrow orifice into the lumen of the urinary tubule, which passes through the labyrinth as a comparatively wide **convoluted tubule** lined with a thick epithelial layer. The tubule then passes into the nearest medullary ray and descends with it in a straight course for a certain distance, then bending suddenly it turns back towards the cortex again. The descending limb of the **Henle's loop** thus formed is very slender and narrow, but the ascending limb widens out again, and at length enters a second wide convoluted tube (the **intercalary tube**) which lies in the cortical layer. The intercalary tube passes into a short and narrow **junctional tube**, and this uniting with others gives rise to the **collecting tubes**. These again unite together into the wider **excretory tubes**, which passing down through the medulla open at the papillae into the **pelvis** or infundibulum of the kidney.

The glomeruli furnish chiefly the water of the urine. The convoluted tubules of the cortex secrete the solid constituents, namely the inorganic salts, urea, uric acid, hippuric acid, kreatinine, xanthine, sarkine, ammonia, colouring-matters, indican, oxalic acid, etc. Some of these substances (such as urea) are contained in the blood, others are elaborated in the kidney. It would appear that the epithelium of the tubules separates these substances from the blood and in an altered or unaltered form gives them up to the water flowing through the tubules from the glomeruli. A certain amount of osmotic diffusion also takes place

between the secreted urine and the blood. Noxious substances in the blood, whether generated within the body or derived from without, are in great measure eliminated by the kidneys. In this way the kidneys act as purifying organs.

If a solution containing about 0·4 per cent. of sodium sulphindigotate is injected into the external jugular vein of a dog, and the animal is killed a few minutes after, it is found that the colouring-matter is already in process of excretion from the kidneys. According to HEIDENHAIN (*Pflüger's Arch.* vol. 9) and PAUTYNSKI (*Virch. Arch.* vol. 79) the excretion first begins in the convoluted tubules, the intercalary tubes, and the ascending limb of Henle's loops. The blue pigment appears in the form of granules in the striated epithelial cells, and stains both the free border and the nucleus. When excretion is in full activity small crystals appear in the cells. When the injection is made some time before death, and is followed by a second large injection of indigo-carmine, the vascular loops and epithelial cells of some of the glomeruli become stained. It thus appears that indigo-carmine may be excreted by the glomeruli.

When a solution of egg-albumen is injected (RUNEBERG, RIBBERT, and others), this substance is excreted by the glomeruli, and the same is true of haemoglobin and sugar. These examples show that matters may pass into the urine both from the glomerular loops and from the intertubular capillaries, traversing in the process the epithelial lining of the glomeruli or of the urinary tubules (compare ADAMI, *Journ. of Physiol.* VI 1885).

521. **Classification according to causation.** The morbid changes affecting the kidney may be appropriately grouped in five classes, according to their mode of origin.

First, we have those affections which are attributable simply to disturbances of the circulation.

Secondly, a group of changes produced by the deposit in the kidney of solid substances, brought to it as such by the blood or precipitated from their solutions.

A third group includes those degenerations and inflammations of the kidney which are due to impurities or disorders of the blood. As the kidney is one of the chief organs by which abnormal substances are eliminated from the blood, it is much exposed to disturbance of its own functions and even to lesions of its structure from this cause: and as a fact a very large number of renal disorders are thus produced.

A fourth group of disorders are traceable to injurious influences affecting the parenchyma of the kidney through the infundibulum. Thus mere obstruction of the outflow of the urine from the bladder may give rise to grave disorder of the kidney. The danger is of course greater when matters that are actively noxious reach the kidney by this route.

The fifth group comprises the tumours or new growths of the kidney.

COHNHEIM and ROY (*Virch. Arch.* vol. 92, *Proc. Camb. Phil. Soc.* IV 1881) have investigated the mechanism of the renal circulation. They find that when a sensory or a splanchnic nerve is stimulated, in asphyxia, and in strychnine-poisoning, the volume of the kidney rapidly diminishes. When the renal artery on one side is tied, no effect is produced on the circulation of the

other. When therefore in cases of loss of one kidney the other takes on the work of both, it is not due to a reflex action but to the effect produced on the circulation of the working kidney by the presence of urinary substances in the blood.

According to the experiments of RIBBERT (*Virch. Arch.* vol. 93) the quantity of urine excreted by a rabbit increases after the removal of the medullary cones. The view that water is re-absorbed from the urine as it passes through the medulla thus receives experimental corroboration.

CHAPTER LXVI.

DISORDERS OF THE RENAL CIRCULATION.

522. **Active hyperaemia** or congestion of the kidneys is due either to increased pressure within the aorta, or to dilatation of the renal arteries.

As the secretion of urine is in the main determined by the pressure and velocity of the blood flowing through the glomeruli, congestion of the kidneys is accompanied by an increase of secretion.

When one kidney is removed or rendered inactive by disease, the other carries on the urinary function unaided. This is of course possible only so long as its blood-supply is permanently increased. A kidney the demands on which are thus permanently increased presently becomes hypertrophied.

This **compensatory hypertrophy** is usually most extreme in cases where the other kidney has failed in early youth; in such cases the normal bulk may be increased as much as twofold. The increase is due chiefly to an increase in the length and calibre of the tubules and to enlargement of the glomeruli, in part also to a multiplication of both these elements. It is said however that multiplication is observed only in cases where one kidney has been lost before birth or in infancy.

Partial atrophy or destruction of a kidney may be followed by hyperaemia and consequent hypertrophy of the sound portion remaining.

The epithelial cells of the dilated and elongated tubules are larger and more numerous than is normal.

References on compensatory hypertrophy of the kidneys :—LEICHTENSTERN, *Berl. klin. Woch.* 24, 1881 ; GUDDEN, *Virch. Arch.* vol. 66 ; BEUMER, *ibid.* vol. 72 ; PERLS, *ibid.* vol. 56 ; RIBBERT, *ibid.* vol. 88 ; GRAWITZ and ISRAEL, *ibid.* vol. 77 ; EPPINGER, *Prag. med. Woch* 36, 1879 ; BOSTRÖM, *Beiträge z. path. Anat. d. Niere* Freiburg 1884.

According to LEICHTENSTERN the diameter of a normal glomerulus measures 135—225 micromm., that of a convoluted tubule 49—79 micromm., and that of a straight tubule 26—49 micromm. In hypertrophied kidneys the first measurement rises to 188—402, the second to 49—141, the third to 49—89 micromm.

The weight of the two kidneys (THOMA, *Untersuch. über die Bestandtheile des Körpers* Leipzig 1882) is in new-born infants about 23 grammes, at six months 44 gm., at twelve months 62 gm., at twenty years 285 gm., at twenty-five 304 gm. In the case of a healthy adult the two kidneys may differ in weight by as much as 30 to 40 gm.

523. **Passive hyperaemia** or engorgement of the kidney is usually the result of some general disturbance of the circulation; it is much less often due to local causes. Affections of the heart and lungs give rise to the former, compression and thrombosis of the vena cava or of the renal veins to the latter. Renal thrombosis most frequently occurs in infants of a few weeks old who die of general marasmus. Compression may be due to the gravid uterus or to an abdominal tumour.

If the outflow of blood from the kidneys is suddenly stopped, they become engorged and greatly swollen, assuming a dark brown or purple hue. Very soon haemorrhages make their appearance, not only in the cortex and beneath the capsule but also in the medulla, Bowman's capsules and the urinary tubules becoming distended with blood.

If the obstruction of the renal veins is gradual, the blood in part finds its way into certain small vessels which pass from the kidney into the capsule and empty themselves into vessels communicating with the phrenic, lumbar, and suprarenal veins. In this way there may be little or no haemorrhage within the kidney but only oedema, very few red blood-cells escaping from the vessels.

If however the obstruction is great and persistent the renal tissues become fatty and necrotic, and presently disintegrate entirely.

When the engorgement is less extreme, as in cases of uncompensated cardiac lesion, the swelling of the kidney is but slight, but its colour becomes dark purple or cyanotic. If this condition persists for any length of time the kidney becomes remarkably dense and firm; at the same time the cortex becomes pale or greyish-red with darker streaks corresponding to the course of the veins. This change is referred to as **cyanotic induration.**

When the engorgement is still recent the vessels are uniformly distended with blood, the veins and capillaries being often greatly dilated. Within the capsule of many of the malpighian bodies and in the lumen of the urinary tubules appears a quantity of liquid, which on boiling yields a granular precipitate of albumen and often contains a few red blood-cells. In some of the tubes lie colourless transparent casts of the lumina, the so-called **hyaline tube-casts** or cylinders. These are simply masses of albumen which have escaped in liquid form with the watery transudation from the glomeruli, and have become solid within the tubules. Some of the epithelial cells, chiefly those of Henle's loops, contain brown and yellow and occasionally crystalline pigment-granules, derived from the colouring-matter of the blood-cells which have

escaped into the tubules and there become dissolved. If the escape of red blood-cells from the glomerular vessels has been recent and unusually abundant the capsules of the malpighian bodies and the tubules connected with them may appear crammed with such pigmentary products of disintegration.

In cases of long-standing engorgement where the kidney is indurated, the intertubular connective tissue is increased in amount, the blood-vessels are wide and flaccid, and the walls of the capillaries and the adventitia of the veins are thickened.

Many of the epithelial cells of the tubules are fatty and contain oil-globules of various sizes. The cells of the straight tubules of the medulla are especially liable to fatty change. The glomeruli appear for the most part unaltered; though here and there a malpighian body is seen whose contents have become homogeneous and shrunken, while the corresponding tubule is narrow, collapsed, or altogether atrophied (see Art. 525).

In engorgement of the kidney the urine is diminished in quantity. The albumen and red blood-cells it contains are derived, according to COHNHEIM and SENATOR, from the capillaries which surround the tubules, the exudation being simply the lymph of engorgement (Art. 24). At a later stage the glomeruli yield a similar albuminous exudation. COHNHEIM regards this as due in some measure to the altered relations of pressure, but in a greater degree to morbid changes in the excretory membrane, namely in the glomerular epithelium. RUNEBERG on the other hand refers the albuminuria of engorgement to a diminished difference of pressure between the contents of the glomerular vessels and those of the capsule of Bowman. This explanation is quite untenable in view of the experiments of BAMBERGER, NEWMAN, and others.

References :—ROBINSON, *Med. chir. Trans.* XXV (1843); JOHNSON, *Diseases of the kidney* London 1852; LITTEN and BUCHWALD, *Virch. Arch.* vol. 66; COHNHEIM, *Allg. Pathologie* II; PERLS, *Arch. f. exp. Path.* VI; HORTOLÈS, *Étude du processus histologique des néphrites* Paris 1881; LITTEN, *Untersuch. über d. haemorrh. Infarct* Berlin 1877; TRAUBE, *Ges. Abhand.* I, II (1871) and III (1878); WEISSGERBER and PERLS, *Arch. f. exp. Path.* VI; SENATOR, *Die Albuminurie* Berlin 1882, trans. by SMITH (New Syd. Soc.) London 1884; POSNER, *Virch. Arch.* vol. 79; HEIDENHAIN, *Hermann's Handb. d. Physiologie* V; GERMONT, Thèse de Paris 1883; RUNEBERG, *Deutsch. Arch. f. klin. Med.* XXIII; BAMBERGER, *Wien. med. Woch.* 1881; NEWMAN, *Journ. of Anat.* XII; CORNIL and BRAULT, *Path. du rein* Paris 1884; ROBERTS, *Urinary and renal diseases* London 1885; VON NOORDEN, *D. Arch. f. klin. Med.* XXXVIII (1886).

524. In general **anaemia**, and in contraction of the renal arteries by thickening or spasm of their walls, the blood-supply of the kidney is diminished, and it becomes anaemic. When the anaemia is considerable the organ becomes pale or greyish, and to some extent translucent. When the blood which reaches it is for any reason irregularly distributed the pale tint may appear mottled with redder patches.

The first result of renal anaemia is diminution of the urine; when the supply of arterial blood becomes very greatly diminished albuminuria appears. This occurs whether the anaemia be due to general causes (as in cholera), or to local arterial spasm (as in

epilepsy, tetanus, asphyxia, pyrexia, or lead-poisoning) COHNHEIM regards it as due to ischaemic degeneration of the glomerular epithelium.

Transient anaemia gives rise to no demonstrable change in the renal structures, but in more chronic conditions degeneration and atrophy of the tubules and glomeruli make their appearance. The deficient supply of blood and consequently of oxygen also leads to fatty change in the renal epithelium, which if it is at all extensive gives the section of the kidney a spotty or mottled appearance If the blood-supply is entirely cut off general necrosis of the tissues ensues (Art 527)

Slight but long-enduring interference with the blood-supply causes the essential elements of the kidney to dwindle and shrink, so that the bulk of the organ as a whole is gradually diminished

525 Renal anaemia, in addition to the epithelial changes it induces, is very often accompanied by **atrophy** and **obliteration** of certain parts of the vascular system of the organ These are most marked when they affect the glomerular capillaries

A normal glomerulus (Fig 202 *b*) appears as a tuft of capillary vessels each covered with an investment of nucleated cells, those of an atrophied or functionless glomerulus on the other hand form a compact more or less homogeneous spherule with few nuclei or none (Fig 202 *d*, Fig 203 *b*) This spherule may show traces of

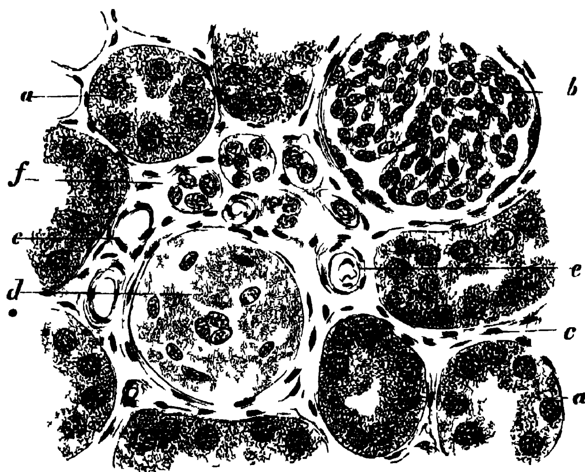


FIG. 202. SENILE ATROPHY OF THE KIDNEY.

(*Section hardened in alcohol, stained with alum carmine, and mounted in Canada balsam*. × 200)

a normal tubule
b normal glomerulus
c vascular stroma
d atrophied and functionless glomerulus
e arteriole with somewhat thickened intima
f atrophied and collapsed tubules

lobulation, but the several capillary loops are no longer distinguishable. So far as we know, the steps of the change are collapse, thrombosis, and hyaline thickening of the capillary-walls; these latter then become fused into a homogeneous mass, the glomerular epithelium meanwhile disappearing. The capsular epithelium persists somewhat longer, but ultimately perishes in like manner, and the collapsed or shrunken capsule comes thus to surround directly the altered glomerulus, without any intervening layer of epithelium (Fig. 203 *b*). The capsule itself is not usually altered: sometimes however a slight thickening takes place, and the wall then looks homogeneous or occasionally fibrillar in structure.

A glomerulus thus reduced to a homogeneous spherule is of course no longer permeable, and the vas afferens is either obliterated or delivers its blood directly to the vas efferens. The corresponding urinary tubule is also rendered functionless, and quickly becomes atrophied. The epithelial cells dwindle, lose their characteristic shape and striation, and are transformed into small cubical cells. They may remain as a regular lining or lie without order in the collapsed lumen of the tubule (Fig. 202 *f*, Fig. 203 *d*).

In some of the tubules the cells become entirely disintegrated (Fig. 203 *e*), or while diminished in size they become fatty, and sprinkled with oil-globules.

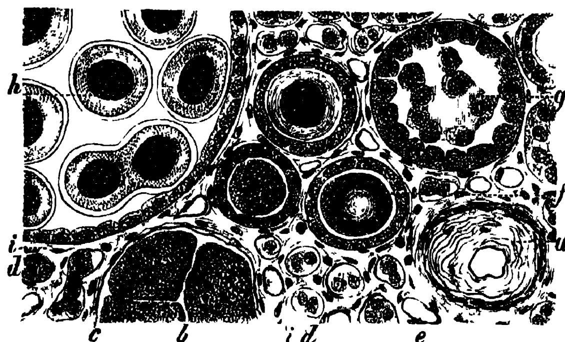


FIG. 203. CONTRACTED KIDNEY WITH ARTERIAL SCLEROSIS.

(*Stained with alum-carmine, mounted in Canada balsam*: × 150)

- *a* artery with thickened and fibrous intima
- *b* obliterated glomerulus denuded of epithelium
- *c* capsule collapsed but not thickened
- *d* tubule collapsed and filled with small cells
- *e* tubule empty and collapsed
- *f* tubules with stratified and unstratified colloid casts and spherules
- *g* dilated tubule containing a homogeneous mass beset with shed epithelium
- *h* cyst containing stratified colloid spherules
- *i* stroma of cells and delicate fibres

In atrophic conditions the altered epithelial cells usually stain very deeply with the ordinary nucleus-staining reagents.

In the lumina of the functionless tubules, straight and convoluted, we frequently find homogeneous **colloid cylinders** and

spherules (Fig. 203 *f h*). Some of these are stratified, others unstratified, and they may be so numerous as to distend the tubule into a small cyst (*h*). So far as can be made out with the microscope these homogeneous masses are a colloid product of the renal epithelium, which is produced either in the form of droplets that afterwards unite, or by a transformation of the entire cell when loosened from its place and carried to another part of the tubule (*g*). The dissolved albumen which flows through the tubule as the degeneration of the glomerulus sets in may have something to do with its formation. When the lumen of a tubule becomes distended with these colloid masses the epithelium becomes flattened and compressed.

Larger colloid masses or agglomerations are visible to the naked eye as translucent yellowish or brownish jelly-like granules, from the size of a pin's head to that of a pea. In rare cases like masses are formed within the Bowman's capsule of the malpighian bodies.

The fibrous tissue of the atrophied region is not increased, but not infrequently there appears to be an accumulation of lymphoid cells in its meshes. It is questionable whether this is an inflammatory process; the impression conveyed is rather that the spaces left free by the collapse of the secreting structures have been partially filled up by indifferent cells.

COHNHEIM and MENDELSON (*Amer. Journ. med. sciences* Oct. 1883) have shown that in pyrexia the kidney becomes markedly anaemic from contraction of the renal vessels.

OVERBECK (*Wiener Sitzungsber.* XLVII) and HERMANN (*ibid.* XXXVI, XLV) have demonstrated that albuminuria results either from a short interruption or a considerable diminution of the circulation through the kidney. The albuminuria persists for some time after the circulation again becomes normal, and COHNHEIM thence argues that the cause is to be sought for in an alteration of the glomerular epithelium.

The vascular loops of the glomeruli are covered with a continuous layer of epithelial cells, which must be regarded as glandular in character, and make the glomerulus in effect a secreting gland. The secretion remains normal only so long as these cells are intact.

The great majority of the nuclei seen in the section of a glomerulus belong to these epithelial cells. The actual capillary-walls are either devoid of nuclei or possess very few indeed.

526. The simple atrophy of the glomeruli and tubules described in the last Article is met with in an uncomplicated form as a senile phenomenon: it is seldom absent in the **kidney of old age**. When the atrophied portions lie near the surface of the kidney they appear as small scar-like depressions, the surrounding parts of the parenchyma being somewhat redder than usual.

Simple atrophy of the secreting structures is also extremely common as an accompaniment of the most various renal affections. It occurs for example in embolic occlusion of the renal arteries, in the various forms of nephritis, and in hydronephrosis. We see it however in its purest form and greatest extension in the

affection which is best described by the term **arteriosclerotic atrophy**.

The renal arteries and their branches in aged persons are very frequently the seat of sclerotic change (Art. 297), which may simultaneously affect the arteries of other regions also, or be confined to those of the kidney. The intima of the vessels thus becomes notably thickened (Fig. 203 *a*, Fig. 204 *e f*) and the lumen narrowed or obliterated: the result is that a certain number of glomeruli become more or less functionless, the number depending on the size of the affected arterial stem. Obstruction of a vas

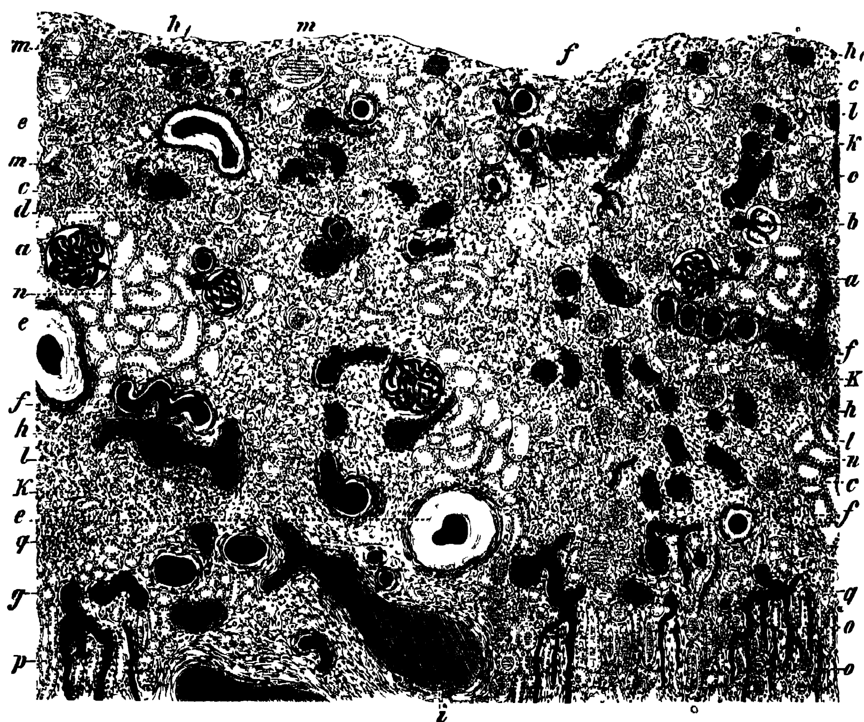


FIG. 204. CORTEX OF AN ARTERIOSCLEROTIC CONTRACTED KIDNEY.

(*Arteries and glomeruli injected with Prussian blue; the section stained with alum-carmine:* × 50)

a normal glomeruli
b c partially and totally atrophied glomeruli without thickening of the capsule
d atrophied glomerulus with thickened capsule
e artery with greatly thickened intima
f interlobular arteries much convoluted and running parallel to the surface of the kidney
g dilated arteries passing down to the medullary zone
h h_1 interlobular and subcapsular veins
i large venous trunk
k atrophied parenchyma with a few shrunken tubules *l*
m cystic dilatation of a tubule with hyaline contents
n normal tubules
o tubules in the medullary ray with hyaline casts
p patent tubules in the medullary ray
q cellular infiltration

afferens will affect only a single glomerulus; constriction of an interlobular artery may cause the atrophy of an entire series.

The morbid changes appear in patches scattered over the kidney according to the distribution of the affected arteries; but occasionally they are so extensive as to affect almost uniformly the whole of the cortical zone.

In slight cases the section shows only a few scattered cicatricial contractions of various sizes, which are usually somewhat redder than the parts around; these latter are pale greyish-red or reddish-brown in tint.

The greater the number of atrophic patches the more numerous are these cicatricial contractions, so that at length the kidney looks granular and roughened on its surface while its bulk is notably diminished. The condition may then be aptly referred to as **arteriosclerotic contraction.**

This form of contraction sometimes reaches an extreme degree, the whole kidney being remarkably small and shrunken, and the cortex reduced to a thickness of one or two millimetres. In such cases the greater number of the glomeruli are atrophied (Fig. 204 *b c d*), and the corresponding tubules (*l*) are collapsed, shrunken, and empty or filled with atrophied epithelial cells. Some of the tubules usually contain hyaline colloid masses, especially in the loops of Henle (*o*), which are often entirely filled with them. The convoluted tubules of the cortex on the contrary seldom contain casts, though here and there they appear dilated into little cysts (*m*) filled with colloid substance. Cases also occur in which the entire parenchyma is beset with small cysts from the size of a millet-seed to that of a pea. The shrinking and warping of the cortex causes the interlobular arteries (*f*) to be distorted and twisted into irregular spirals, while here and there some of them are so displaced as to run nearly parallel to the surface. Most of them show a more or less marked thickening of the intima (*e f*).

When the vascular system of the cortex is thus damaged or obliterated by the obstruction of the glomerular and interlobular capillaries, the vessels running towards the medullary zone (the arteriae rectae (*g*)) become widely dilated, and the greater part of the blood-stream passes directly through the medulla.

In the arteriosclerotic kidney there is little or no hyperplasia of the connective tissue, and the capsule of Bowman is seldom perceptibly thickened. Here and there however the connective tissue shows patches of cellular infiltration (*q*).

GULL and SUTTON (*Med. chir. Trans.* LV 1872) were the first to call special attention to the arterial changes associated with contracted kidney; they described the condition as 'arterio-capillary fibrosis.' Their statements were however somewhat lacking in precision, and they did not sufficiently distinguish between primary arteriosclerosis and the secondary form associated with interstitial nephritis. Dr GEORGE JOHNSON (*Lectures on Bright's disease* London 1873) drew attention to the hypertrophy of the muscular coats of the arterioles in certain chronic kidney diseases; he interpreted the vascular

change as secondary. In Germany THOMA and EWALD (*Virch. Arch.* vol. 71) minutely investigated the vascular changes in contracted kidney, but they too failed to keep distinct the various forms of the affection. ZIEGLER (*Deutsch. Arch. f. klin. Med.* XXV) first discussed in detail the great importance of primary changes in the vessels in determining the contraction of the kidney, and showed that primary sclerosis gives rise to a special form of contraction, for which he accordingly suggested the term arteriosclerotic atrophy. LEYDEN has recently (*Zeitschr. f. klin. Med.* II, and ROSENSTEIN, *Trans. internat. med. Congress* II London 1882) examined the subject very fully, and proposes to call the affection renal sclerosis. ZIEGLER objects to this term on the ground that sclerosis of an organ implies induration, and the absence of induration in the arteriosclerotic kidney is what essentially distinguishes it from the cirrhotic contracted kidney. See also HOLSTI (*D. Arch. f. klin. Med.* XXXVIII 1885), and GULL (*Amer. Journ. med. sci.* 1886).

The vascular change as we have seen begins usually in the arterioles. There is however evidence that the glomeruli may be the seat of primary sclerosis, the capillaries becoming obstructed by a hyaline thickening of their walls. It is worthy of note that arteriosclerotic contraction is very common among workers in **lead**, especially in the young; the sclerotic change is most marked in the smallest vessels and in the glomeruli. It would thus appear that lead has a selective degenerative action on these parts of the vascular system. The affection is usually accompanied by symptoms of gout. See OLLIVIER (*Archives générales de méd.* 1863), DANJOY (*ibid.* 1864), TRAUBE (*Allg. med. Centralzeitung* 1861), DICKINSON (*Diseases of the kidney* II London 1877), HOFFA (*Ueb. Nephritis saturnina* Freiburg 1883), CHARCOT and GOMBAULT (*Arch. de physiologie* 1881), WAGNER (*Ziemssen's Handb. d. spec. Path.* 3rd edition IX), GARROD (*Gout and rheumatic gout* 3rd edition London 1876).

Arteriosclerotic contraction is very gradual in its progress. Albuminuria is slight or absent altogether. Cardiac hypertrophy may ensue as in other atrophic affections of the kidney. For cases see LEMCKE (*Deut. Arch. f. klin. Med.* XXXV, with references), SCHUCHARDT (*Berl. klin. Woch.* 41, 1882).

527. The renal vessels having no arterial anastomoses, when a renal arteriole is blocked by an embolus **embolic infarction** ensues. Immediately after the stoppage of the circulation through the region supplied by the embolised vessel there is no apparent change in the renal tissue. In a few hours however the starved tissue dies, and gradually assumes a turbid greyish or yellowish tint. Presently there is more or less extensive hyperaemia and haemorrhage and the pallor of the dead tissue disappears at least in part. LITTEN'S investigations show that the haemorrhage takes place chiefly from the capillaries, and is in fact an extravasation from engorgement (Art. 30). The blood in the capillaries of the embolised region being derived solely from the neighbouring capillaries the pressure is insufficient to drive it through them into the larger veins; stasis ensues, and soon the capillaries and venules are distended with blood, which at length escapes into the surrounding tissue. The extravasation takes place mainly from the intertubular capillaries, but blood-cells and plasma may escape from the glomeruli likewise and accumulate within the capsules and tubules. COHNHEIM and GUILLEBEAU have sought to make out that a certain amount of reflux takes place from the veins of the embolised region.

The haemorrhage may be slight and limited to the marginal zone of the region, or it may be great and extend over the whole of it. In the latter case the entire patch becomes uniformly dark-red or mottled with red and grey. Very soon however this appearance changes, the centre of the patch becoming rapidly pale again by the diffusion and absorption of the colouring-matter of the blood. The infarct then closely resembles a simply anaemic patch.

In a few days after the embolism the infarct appears as a more or less regularly-shaped wedge or cone of a dull yellowish or greyish tint, surrounded by a zone of haemorrhagic infiltration. Sometimes a narrow white zone intervenes between the latter and the pale centre. This white zone contains vessels filled with plasma and a great multitude of white blood-cells. The base of the cone is always directed outwards, and its apex is rounded off.

The size of the infarct depends on the size of the obstructed artery. The smallest may be no larger than a millet-seed; more commonly they are larger, measuring from 4 to 10 mm. at the base, and extending to the middle of the cortex or even to the boundary zone; now and then they are so large as to include a third or more of the whole kidney.

The renal epithelium perishes some two hours after the circulation ceases (LITTEN); it becomes homogeneous, or turbid and granular, and ceases to take up staining-reagents. The nuclei become pale and indistinct, and ultimately dissolve or break up into fragments. At first the dead cells retain their normal place and arrangement, but presently some of them break away from their attachment to the membrana propria of the tubule and are transformed into structureless flakes and blocks, or they crumble into amorphous granules. Sometimes a part of the necrosed and detached epithelium becomes calcified. Meanwhile the intertubular connective tissue swells, being pervaded with liquid and blood-cells or granular detritus. The former are met with chiefly in the red marginal zone, the latter in the pale centre. The nuclei of the connective tissue are pale and some of them lose their outline, while the membrana propria of the tubules is more or less swollen up.

The glomeruli remain for a considerable time unaltered, but by and by they too lose their nuclei and are transformed into colourless spherules in which the constituent parts are no longer distinguishable. When blood has escaped from the glomerular capillaries into the capsule and its tubule, the blood-cells may disintegrate into granular masses which form brownish casts of the lumen. But these are never numerous, and are often absent.

528. The changes just described take place of course only in the region where the tissue perishes, that is to say in the central parts and in a portion of the marginal zone of the infarct. This region gradually becomes disintegrated and liquefied, its structural elements losing their distinctness more or less completely.

Even the fibrous structures and the glomeruli may in extreme cases break down and ultimately dissolve like the rest.

Notwithstanding this a focus of true colliquative softening is seldom produced, inasmuch as the products of disintegration and liquefaction are absorbed as fast as they appear. The epithelial cells are the only elements which disappear entirely over any considerable area, the fibrous tissue and glomeruli in great part remain undissolved, though of course they are greatly altered. In the smaller infarcts no part of the fibrous structure entirely disappears.

The necrosis and disintegration of part of the tissue is accompanied by degenerative changes, chiefly fatty, of other parts. They are later in appearing, and affect the elements which do not at once undergo necrosis. The renal epithelium, the glomeruli and their capsules, and the fibrous stroma appear beset with oil-globules, though the fatty change never becomes extensive or extreme. Fatty degeneration may affect those glomeruli whose vessels remain intact as well as those where obstruction or obliteration has taken place Collapsed and functionless tubules occasionally become distended with oil-globules, which may also make their appearance in the lumen of tubules that remain healthy.

Some portions of the embolised region may promptly receive a supply of blood from the neighbouring capillaries or from the vessels of the capsule which penetrate the tissue of the organ (LITTEN, PAUTYNSKI) In other parts the interrupted circulation may in a few days be partially restored by the opening up of collateral channels, or of the obstructed vessel itself through shrinking or absorption of the embolus The restoration of the circulation can hardly ever (at least in the larger infarcts) be sufficient to repair fully the damage done to the renal tissue. Some of the tubules and glomeruli always perish outright, or become so atrophied that they no longer perform their functions.

Complete restoration of an embolised region is in fact possible only when the normal circulation is very speedily re-established. If a glomerulus be permanently obstructed its tubule can no longer be restored to its normal state. If the conditions are so favourable that its epithelium once partially degenerated is reproduced by multiplication of the remaining cells, the new elements remain small and functionless. The same is true of the epithelial elements which do not perish outright, if the circulation through the corresponding glomerulus is permanently interrupted.

The loss of tissue brought about by the embolism results in the formation of a contracted cicatrix, which looks grey or reddish according to the blood it contains, and in later stages may become slaty-grey or brown from pigmentation.

In large infarcts extending through the whole thickness of the cortex the centre of the cicatrix shows no trace of renal structure, but is occupied entirely by fibrous tissue partly representing the

original stroma and partly of new formation. Whitish fibrous nodules with few nuclei represent the glomeruli, the capsule of Bowman being no longer recognisable. There are no tubules, the only trace of their existence being clefts or streaks devoid of epithelium scattered through the cicatrix. The larger arterioles are collapsed and impermeable, and ill-defined against the surrounding fibrous tissue.

Surrounding the obliterated region is an irregular zone within which the fibrous stroma is increased, the glomeruli reduced to homogeneous denucleated impermeable spherules, and the tubules collapsed.

The altered glomeruli are enclosed in a capsule which is either normal or consists of thickened fibrous tissue disposed in concentric strata: in recent infarcts the glomeruli may show a few scattered oil-globules. The tubules are either empty or contain small epithelial cells, usually lying without regular order in the lumen. Here and there towards the margin of the infarct tubules containing fatty epithelium are seen.

The intertubular fibrous tissue is always increased; in parts it is dense and coarsely fibrous, in others soft and beset with numerous round-cells. The latter are more numerous as the cicatrix is recent or imperfectly developed. Pigment is seldom present, though occasionally it appears in the form of granules and crystals.

The boundary between the cicatrix and the healthy tissue is seldom sharply defined, but the transition from normal to atrophied tissue is sufficiently clear. The neighbouring healthy tubules sometimes contain hyaline casts.

The cicatrix is due to the absorption of the dead and degenerate tissue, which is only to a very slight extent regenerated, and to hyperplasia of the fibrous structures.

The number and magnitude of the embolic cicatrices determine the degree of distortion which the kidney as a whole undergoes by their contraction. When they are numerous and large the bulk of the organ may be considerably diminished, and a form of contracted kidney which we may appropriately call the **embolic contracted kidney** is produced. It is always characterised by the irregularity of the contraction.

Emboli containing infective matters give rise to metastatic abscesses (Art. 543).

References :—KIRKES, *Med. chir. Trans.* XXV (1842); BECKMANN, *Virch. Arch.* vol. 20; CORNIL and RANVIER, *Man. d'hist. path.* Paris 1878; ARGATINZKI, *Beiträge z. norm. u. path. Anat. d. Niere* 1877; UTTHOFF, *Exp. Beiträge z. Nephritis* In. Diss. Berlin 1881; LITTEN, *Zeitschr. f. klin. Med.* I (1879), *Unters. üb. d. haem. Infarct* Berlin 1879; COHNHEIM, *Allg. Path.* I Berlin 1882; WEIGERT, *Virch. Arch.* vols. 72, 79; GUILLEBEAU, *Ueber d. Hist. d. haem. Infarcte* Berne 1880; GRAWITZ and ISRAEL, *Virch. Arch.* vol. 77; TALMA, *Zeitschr. f. klin. Med.* II (1880); PAUTYNSKI, *Virch. Arch.* vol. 79; HAMILTON, *Liverpool Med. chir. Journ.* July 1883 (who questions the

existence of a haemorrhagic stage); Mögling, *Zur Entstehung d. haemorrhagischen Infarcts* Jena 1884 (with an admirable summary of the literature).

Litten has shown experimentally that the renal epithelium dies if deprived of blood for two hours. If the deprivation is of shorter duration it becomes for a time incapable of performing its functions. When the anaemia is maintained for six to eight hours the connective-tissue elements likewise perish. In rabbits and dogs the epithelium when killed by temporary ligature of the renal artery is in part detached from the tubules and forms epithelial casts which ultimately become calcified.

The urine secreted by a kidney in this state of anaemic degeneration and necrosis is found to contain albumen. Litten holds that the albumen is derived from the degenerate epithelium, inasmuch as the glomeruli are apparently unaltered. This theory cannot be confuted, but it does not seem necessary, seeing that the admitted degeneration of the glomerular epithelium suffices to explain the escape of albuminous liquid from the capillaries. See also von Werra, *Virch. Arch.* vol. 88.

CHAPTER LXVII.

RENAL DEPOSITS DERIVED FROM THE BLOOD.

529. Deposits in the renal tissue of **solid or corpuscular matters** coming from the blood are of three kinds.

In the first place they may consist of foreign substances circulating in the blood. Secondly, they may consist of constituents of the blood which have abnormally escaped from the blood-vessels, in consequence of morbid changes in the parenchyma of the kidney. Thirdly, substances normal or morbid, which in health remain dissolved, may under special conditions be precipitated in the solid form within the kidney. In many cases two or all three of these forms of deposit are met with simultaneously.

Substances abnormally escaping from the blood-vessels are deposited in the fibrous stroma or in the tubules, whence they may ultimately reach the collecting tubes and the pelvis of the kidney. From the pelvis they may be at once carried off to the bladder, or they may remain for a considerable time.

Many deposits give rise to an appreciable alteration of the renal structures. Others induce more or less extensive degenerations, or inflammations. In this respect the behaviour of bacteria reaching the kidney from the blood is very various. Anthrax-bacilli may crowd the renal vessels without giving rise to degenerative or inflammatory change, while the micrococci of pyaemia at once set up intense inflammation and wide-spread necrosis (Art. 543).

According to LITTEN bacteria may so multiply and accumulate in the Bowman's capsules and in the tubules as to distend them and effectually block them up.

530. **Leukaemic infiltration** of the kidney is one of the results of leukaemia (Art. 260); it is characterised by an accumulation of white blood-cells in the renal tissue. When the infiltration is well marked the kidney becomes pale-grey in colour and is somewhat swollen; or greyish nodules appear scattered through it.

See VIRCHOW (*Gesammelte Abhandl.* Frankfort 1856), FRIEDREICH (*Arch. f. path. Anat.* XII), BÖTTCHER (*ibid.* XIV), RINDFLEISCH (*Path. Hist.* II London 1873), GREENFIELD (*Trans. Path. Soc.* XXIX 1878).

Haemorrhagic infiltration is usually due to extravasation of blood from the glomeruli, or more rarely from the intertubular capillaries. As the blood escapes from the capsule of the malpighian body into its tubule (Art. 544, Fig. 213) the infiltration takes the form of reddened streaks and specks of the size of a millet-seed Such extravasations are due partly to disturbances of the circulation, partly to alterations or degenerations of the glomeruli; but large haemorrhages from the glomeruli are seldom due to mere disturbances of the circulation, except in the case of embolism. Blood which has escaped from a glomerulus, especially if it is considerable in quantity, usually becomes disintegrated within the tubules, forming granular yellowish or brownish casts of their lumina. After a time yellow or brown pigment granules also appear. As these lie chiefly within the epithelial cells (Art. 544, Fig. 213) we must apparently assume that the pigment is formed in the cells from the diffused colouring-matter of the blood. It is however possible that the cells may take up pigment-granules lying free within the tubules This secondary condition is referred to as **pigmentary infiltration**.

Blood-cells, whether entire or disintegrated, which reach the pelvis of the kidney through the collecting tubes are in general speedily removed with the urine. It is only when a large intra-renal haemorrhage has taken place, or when the mucous membrane of the pelvis itself is the source of the bleeding, that fibrinous coagula are produced, and then they take the form of tough dirty-white, yellow, or brown clots.

If as described in Art 262 a solution of haemoglobin in the blood-plasma has taken place, the dissolved haemoglobin and methaemoglobin are excreted through the kidney (haemoglobinuria). At the same time we find in the tubules deposits of lustrous reddish-yellow or brownish globules of haemoglobin, yellow and brown pigment-granules, and less frequently red blood-crystals. This form is also described as pigmentary infiltration, but more fitly perhaps as **haemoglobin infarction**.

The pigment-granules are partly deposited as such from the blood, partly precipitated from the dissolved colouring-matter in the process of excretion. In the deeper parts of the kidney these products of disintegration of the blood become aggregrated into brownish granular tube-casts: the globules of haemoglobin form homogeneous pale-yellow casts.

A third form of pigmentary deposit, **biliary infiltration**, is due to the precipitation of yellow or brown amorphous granules and flakes of bile-pigment. It is a result of icteric contamination of the blood. These granules lie for the most part within the epithelial cells, especially those of the convoluted tubules. Sometimes crystals of bilirubin are formed; this is most frequently observed in cases of *icterus neonatorum*.

These colouring-matters may give the kidney a dark-brown

(from methaemoglobin) or a yellow or brownish-yellow tint (from bile-pigment). Deposits of amorphous and crystalline pigment appear to the eye as small reddish-brown to black, yellow, yellowish-brown, or yellowish-red spots and streaks. In adults these are most numerous about the cortex, in infants chiefly in the medulla about the neighbourhood of the papillae.

A peculiar form of pigmentation, known as **argyrosis** or silver-staining, is due to the deposit of silver-particles in cases where preparations of the metal have been medicinally administered. The particles lie chiefly in the medullary zone, and give it a dark-grey tint.

Small haemorrhages and pigmentary deposits cause no perceptible injury to the renal tissue. Larger haemorrhages and extensive deposits of methaemoglobin and pigment may give rise to obstruction of the tubules and degeneration of the epithelium.

References:—PONFICK, *Berl. klin Woch* 17, 1876 and 46, 1877, *Virch. Arch.* vols. 62, 88, LESSER, *ibid* vol. 79; MARCHAND, *ibid.* vol. 77; NEISSER, *Zeitschr. f. klin. Med.* I; ADAMS, *Haemoglobinausscheidung in den Nieren* In. Diss Berlin 1880; BOSTROM, *Ueb d. Intoxication durch d. essbare Morchel* Leipzig 1882, *Deut Arch f. klin Med.* XXXII; LEBEDEFF, *Virch. Arch.* vol. 91; LUCHSINGER, *Pfluger's Arch.* vol. 11; BOHM, *Arch f. exp. Path.* VI; MASIUS, In. Diss. Breslau 1882; LICHTHEIM, *Sammlung klin. Vortrage* 134; JACOBI, *New York Med. Rec.* 11, 1879; DRESCHFELD, *Trans. internat. med. congress* I London 1881; AFANASSIEW, and BOAS, *Arch. f. klin. Med.* VI 1883, *Virch. Arch* vol 98.

After transfusion of blood from another animal (PANUM, PONFICK), after severe burns (PONFICK, LESSER, LICHTHEIM), poisoning with the morel mushroom (BOSTROM, PONFICK), and subcutaneous injection of glycerine (LUCHSINGER), haemoglobinuria has been observed; and after poisoning with potassium chlorate methaemoglobinuria (MARCHAND, LEBEDEFF, JACOBI, DRESCHFELD). According to the recent researches of PONFICK (*Congress f. innere Medicin* Wiesbaden 1883) haemoglobin is excreted not only by the glomeruli but also by the renal epithelium; see also ADAMI (*Journ. of Physiol.* VI 1885).

The obscure affection known as intermittent or **paroxysmal haemoglobinuria** appears to be associated with no recognisable anatomical alteration of the kidney other than haemorrhagic and pigmentary infiltration and congestive hyperaemia. See the references in Art. 262; also MURRI, *Della emoglobinuria da freddo* Bologna 1880; COHNHEIM, *Allg. Path.* II Berlin 1882; S. MACKENZIE, *Lancet* 1, 1884; DICKINSON, *Renal and urinary affections* III London 1885; ROBERTS, *Urinary and renal diseases* London 1885.

531. **Uric acid**, whether produced in normal or abnormal quantity (as in gout), may be deposited in the kidney in the solid form or as solid urates when the water excreted is incapable of holding it all in solution. This is especially apt to take place (according to VOIT and HOFFMANN) when the urine becomes acid by fermentation, and acid sodium phosphate being present decomposes the alkaline urates of the urine to form basic phosphate.

The deposit consists partly of uric acid, partly of urates and especially sodium urate: it takes the form of amorphous granular masses or of acicular crystals. These lie in the tubules, chiefly the collecting tubules, and partly in the connective tissue.

The smallest deposits are not visible to the unaided eye. More abundant precipitation gives rise to the powdery or coarsely granular deposits known as gravel or to renal calculi.

Uratic deposits are most frequently met with in new-born infants, especially such as die two to fourteen days after birth. In the first two days of life and in infants who have not breathed they are rarely found. Apparently the rapid metabolic changes which take place after birth are accompanied by the production of so much uric acid that the urine is incapable of holding it all in solution. These deposits in infants are sometimes described as **uratic infiltration**. They consist of ammonium and sodium urates; they lie in the medullary zone, and appear as pale yellowish-red streaks.

In adults the uratic deposits usually take the form of sand or **gravel**, and lie both in the cortex and the medulla, as well as in the calices and pelvis of the kidney: they vary greatly in amount in different cases. In the calices and pelvis they often become aggregated into concretions from the size of a pea to that of a hazel-nut, and are then known as **renal calculi**. Occasionally these take the form of large branching casts of the infundibulum and its ramifications, and then look something like masses of coral.

Uratic calculi are hard, yellow brown or red in colour, and are smooth or slightly nodular on the surface. Small calculi have a crystalline fracture, but the larger ones are amorphous and often wood-like in texture. These deposits whether in the substance of the kidney or in its pelvis may give rise to disorders of secretion or to inflammation (Art. 555).

References on uratic deposits :—GARROD, *On gout and rheumatic gout* London 1876; HELLER, *Die Harnconcretionen* Vienna 1860; NEUBAUER and VOGEL, *Analyse d. Harns* Wiesbaden 1881; SALKOWSKI and LEUBE, *Die Lehre vom Harn* Berlin 1882; CHARCOT, *Leçons sur les maladies du foie et des reins* Paris 1877; COHNHEIM, *Allg. Path.* II Berlin 1882; SENATOR, *Ziemssen's Cyclop.* XVI; EBSTEIN, *ibid.* XV, and *Die Natur u. d. Behandlung d. Gicht* Wiesbaden 1882, trans. by SCOTT, London 1885; VIRCHOW, *Berl. klin. Woch.* 1884; DICKINSON, *Renal and urinary diseases* III London 1885; RALFE, *Diseases of the kidneys* London 1885.

On uratic infiltration in infants :—VIRCHOW, *Gesammelte Abhandlungen* Frankfort 1856; SCHLOSSBERGER, *Arch. f. physiolog. Heilk.* IX (1850); B. SCHULTZE, *Deutsche Klinik* 1858; RAPHAEL, *Brit. Med Journ.* 1, 1870; LIMAN, *Handb. d. gerichtl. Med.* II (1882).

According to the researches of CARTER (*Urinary calculi* London 1873), ORD (*Influence of colloids* London 1879), EBSTEIN (*Congress f. innere Med.* Wiesbaden 1883) all uratic concretions contain a colloid or albuminoid matrix, in which the various salts are deposited and by which they are cemented together.

532. Concretions of calcium phosphate and carbonate deposited in the kidney constitute what is called **calcareous infiltration**. It occurs chiefly in aged persons, in whom resorption of the bony structures is active; but it may occur without such resorption. The deposits are in the form of white grains, spherules, and nodules, and lie for the most part in the looped tubules of the medullary

zone, though some may be observed in the cortical tubules, in the fibrous stroma, and even in the glomeruli.

Calcium phosphate may form gravel and small calculi in the pelvis of the kidney; the calculi are smooth and facetted, and of various degrees of hardness.

Calculi of calcium carbonate are very rare; they are brown or yellow and hard. This salt however not infrequently forms a constituent of other kinds of calculi.

Oxalic acid, whether ingested with the food or formed from the decomposition of uric acid, may be deposited in the kidney or its pelvis as 'dumb-bells' or octahedral crystals of calcium oxalate. This occurs when the amount of acid sodium phosphate in the urine is insufficient to maintain in solution the quantum of oxalic acid present. Within the kidney the oxalate forms white deposits. In the pelvis it forms pale or dark brown warty or spiny calculi. Pure oxalate calculi are very rare. The salt more frequently occurs as a constituent of uratic calculi.

Triple-phosphate of ammonium and magnesium occurs as soft crumbly white concretions, seldom pure, but frequently forming a coating on uratic calculi. The deposit is produced chiefly in ammoniacal decomposition of the urine; ammonium carbonate is first formed, and this precipitates the earthy and ammonium phosphates. The crystals of the triple-phosphate have usually the so-called 'sarcophagus-form', derived from a rectangular prism by cutting off the angles and edges.

In rare cases renal concretions and calculi are found which consist of **cystine**, an abnormal constituent of the urine containing sulphur and crystallising in hexagonal plates. They have rounded corners, are soft and wax-coloured, and show a radiate crystalline fracture.

Xanthine calculi are extremely rare: they are pale or dark brown, very hard, and not unlike uratic calculi.

In one case (ORD, *Trans. Path. Soc.* XXIX 1878) a concretion consisting chiefly of **indigo** has been found in the kidney.

All the forms of renal concretion and calculus may give rise to inflammation, and occur on one side or on both The condition of a kidney containing a calculus in its pelvis is frequently referred to as **nephrolithiasis** (Art. 553).

References:—BENEKE, *Die Oxalurie* Gottingen 1852; NEUBAUER and VOGEL, *loc. cit.*; SALKOWSKI and LEUBE, *loc. cit*; A. FRANKEL, *Zeitschr. f. klin. Med.* II; LITTEN, *Virch. Arch.* vol. 80; ROBERTS, *loc. cit.*; WAGSTAFFE, *Trans. Path. Soc.* XIX (1868); BEALE, *Urinary deposits* (plates) London 1883; DICKINSON, *loc. cit.*; ROBERTS, *loc. cit.*

LITTEN asserts that masses of micrococci within the glomeruli and tubules may become calcified. The calcareous deposit in the glomeruli, tubules, and renal epithelium may be so excessive that the function of the kidney is gravely interfered with.

533. When the glomeruli and their epithelium are seriously injured, or the circulation through them greatly disturbed, certain

components of the blood may escape from their vessels which normally are held back. In like manner substances may escape from the intertubular capillaries into the tubules. This is most notably the case with regard to the **serum-albumen** of the blood, which in morbid conditions passes in greater or less amount into the urine (**albuminuria**).

This albumen comes from the glomeruli in the soluble form; but within the tubules it may coagulate and thus give rise to granular or homogeneous casts, especially in the region of the loops of Henle, but often in other parts also. These casts are known as **hyaline casts** or cylinders, and there is no doubt that they may consist exclusively of transuded serum-albumen, though they are also formed in other ways.

In many affections of the kidney, especially those of an inflammatory kind, the renal epithelium degenerates or breaks down and desquamates. Moreover we know that from the glomeruli and tubules there escape not only serum-albumen but also white blood-cells. In many morbid affections therefore the tubules contain not only soluble albumen but also albumen derived directly from the protoplasm of cells, and this albumen like the other may take part in the formation of tube-casts. In the first place, the desquamated epithelial cells become agglutinated into casts of the tubules: these have received the name of **epithelial casts**. So also the granular albuminoid and fatty products of their disintegration may in like manner give rise to **fatty casts**. Again the epithelial cells and leucocytes or their albuminous detritus may become transformed and fused into compact hyaline masses, or homogeneous masses may escape from the bodies of the degenerating cells and coalesce into homogeneous cylinders. Finally, both epithelial cells and extravasated leucocytes dissolve in the albuminous urine flowing through the tubules, and in this form play their part in the production of casts. The **granular casts** derived from blood-disintegration have already been spoken of (Art. 530).

Tube-casts may in certain circumstances be washed out of the tubules, and so escape from the kidney. The greater number however remain *in situ*, and are either redissolved or become more firm and dense so as somewhat to resemble wax (**waxy casts**). These occasionally give the reaction of the amyloid substance.

In addition to these casts, formed at least in part from transuded albumen, we may have homogeneous cylinders which are purely epithelial in their origin. These have been described in Art. 525 (Fig. 203) as **colloid casts**.

References on the formation of tube-casts: BAYER, *Arch. d. Heilk.* 1868; AXEL KEY, *Schmidt's Jahrb.* vol. 114 (1867); BURKHART, *Die Harncylinder* Berlin 1874; AXEL KEY and LANGHANS, *Virch. Arch.* vol. 76; BARTELS, *Ziemssen's Cyclop.* XV; WEISSGERBER and PERLS, *Arch. f. exp. Path.* VI; FINLAYSON, *Brit. For. Med. Rev.* Jan. 1876 (on tube-casts without albuminuria); ROVIDA, *Moleschott's Untersuch.* XI; HUPPERT, *Virch. Arch.* vol. 59;

RIBBERT, *Cent. f. med. Wiss.* 1879, *Nephritis u. Albuminurie* Bonn 1881; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* IV; WEIGERT, *Sammlung klin. Vorträge* 162, 163; POSNER, *Cent. f. med. Wiss.* 1879, *Virch. Arch.* vol. 79; CORNIL, *Journ. de l'anat.* 1879, *Practitioner* XXVIII (1882); SAUNDBY, *Birmingham Med. Review* Sep. 1883 (with references); KNOLL, *Zeitschr. f. Heilk.* V.

The formation of casts from epithelial cells has been specially investigated by LANGHANS. He showed that the glomerular epithelium may furnish the material. The cells are shed into the lumen of the capsule, reach the tubule, and break up into granular masses: these presently become clear and swell up, and coalesce into homogeneous cylinders.

CHAPTER LXVIII.

RENAL DEGENERATION AND NECROSIS.

534. When poisonous or otherwise noxious matters are excreted by the glomerular and renal epithelium, or when the nutrition of the renal tissue is impaired in consequence of changes in the blood or in the circulation, degenerative changes make their appearance in the glomeruli and tubules, and these changes are generally demonstrable by careful microscopic examination. The

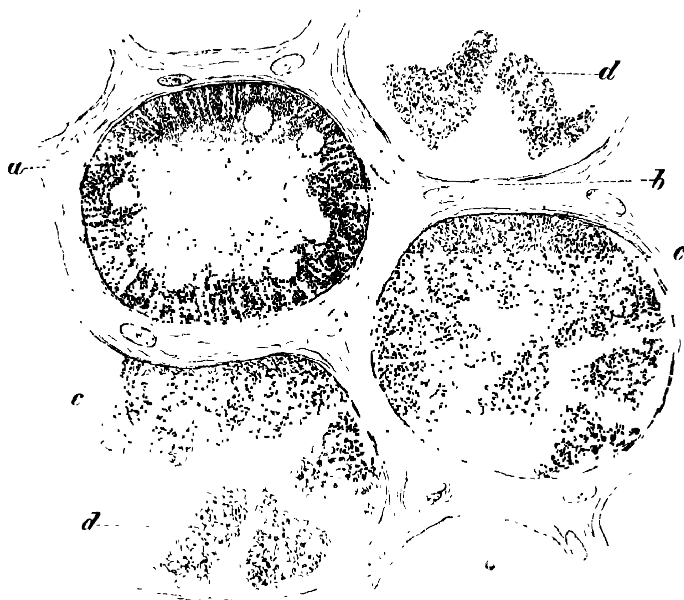


FIG. 205. CLOUDY SWELLING OF THE RENAL EPITHELIUM.

(*Preparation treated with chromic acid and ammonia:* × 800)

a normal epithelium
b cloudy swelling commencing
c cells in extreme degeneration
d loose degenerate epithelium

most frequent changes are—cloudy swelling, necrosis, and fatty degeneration.

Cloudy swelling. The epithelial cells (Fig. 205 *a*) of the convoluted tubules are usually wedge-shaped or conical; by broadening of the apex they may become more cylindrical, and by expansion of the base somewhat mushroom-shaped. The outer (parietal) half of each cell is striated with radial rod-shaped markings, due either to differentiation of the cell-protoplasm into two substances of different refractive power, or to splitting and fibrillation. The inner (apical) half of the cell is homogeneous or finely granular, and in some cases terminates in a process (*a*), which ends in a free point or flattened plate, or joins with other projections, or simply lies over on the apex of the neighbouring cell.

In the ascending limb of Henle's loops the cells are similar in form but somewhat shorter; in the descending limb the striated portion of the cell is contracted to a kind of basal plate. The epithelium of the intercalary tubules and collecting tubes is unstriated.

The condition known as cloudy swelling is accompanied by a slight enlargement of the kidney, the cortex assuming a turbid grey or greyish-red tint something like the tint of renal anaemia, but less translucent. If the interlobular veins contain blood the section appears streaked with red, while the medulla is generally livid.

When the affection first sets in the striated cells of the cortex become more markedly granular (*b*). The striations become less fine (NAUWERCK) and then appear to break up into granules. Then the apical part of the cell becomes granular, the whole cell swells up, and loses its normal shape. The processes become swollen, and are ultimately effaced. The nucleus soon becomes distended to a clear vesicle and disappears, and the cell looks uniformly turbid and granular (*c d*). At this stage the cells become loosened from each other, and somewhat raised up from their basal membrane. At length oil-globules may make their appearance in the body of the cell, which then breaks up and dissolves. In the convoluted tubules the first minute oil-globules usually appear at the bases of the cells; in the collecting tubes they appear round the nucleus (NAUWERCK). This series of changes is very frequently met with in infective fevers such as typhus, small-pox, purulent meningitis, erysipelas, septicaemia, diphtheria, etc. and usually extends over the greater part of the cortex. If the change has not gone far the cells may recover; but where the associated dropsical or fatty degeneration has taken place the epithelium can only be replaced by regenerative multiplication.

The glomeruli and their epithelium usually show no visible change, though now and then some of the cells look swollen, turbid, and granular or powdered. It is also worthy of note that in some cases haemorrhage may occur from the glomeruli, distending their capsules and tubules with blood, and giving rise to red streaks and spots on the section of the cortex. These haemorrhages are due either to obstruction of the capillary circulation in the swollen parenchyma, or to degeneration of the glomeruli themselves.

When the cloudy change has advanced to fatty degeneration in the tubular epithelium, that of the glomeruli and their capsules may also become fatty.

In the above account of the degenerative changes affecting the renal epithelium no reference has been made to the statements of other authors on the subject; the account rests solely on the observations made in ZIEGLER'S own laboratory in collaboration with NAUWERCK. In many memoirs on the subject no mention is made of the mode of preparation adopted, or hardening-fluids and reagents have been used which greatly alter the renal epithelium. Alcohol especially is entirely inadmissible in such investigations.

References :—KLEBS, *Handb. d. path. Anat.*; RINDFLEISCH, *Path. Histology* II (New Syd. Soc.) London 1873; PONFICK, *Berl. klin. Woch.* 1876-77, *Virch. Arch.* vol. 88; BOSTROM, *Ueber d. Intox. durch d. essbare Morchel* Leipzig 1882; BARTELS, *Ziemssen's Cyclop.* XV; WAGNER, *ibid.* (3rd German edition) IX; BRAULT, *Journ. de l'anat.* XVI; ECKSTEIN, *Deutsche med. Woch.* 1882; GAUCHER, *Lancet* 1, 1881; JACOBI, *Gerhardt's Handb. d. Kinderkrankh.* II; THOMAS, *ibid.* IV; WEIGERT, *Sammlung klin. Vorträge* 162, 163; MARCHAND, *Virch. Arch.* vol. 77; LEBEDEFF, *ibid.* vol. 91; P. FÜRBRINGER, *ibid.* vol. 91; LASSAR, *ibid.* vol. 77; NAUWERCK, *Beiträge z. Kenntniss d. Morbus Brightii* Jena 1884.

535. **Dropsical degeneration** of the renal tissue, and especially of the epithelium, plays a great part in the pathology of the kidney. The glomerular epithelium (Fig. 207) and that of the convoluted tubules (Fig. 206) is the most frequently affected, less frequently that of the straight tubules and collecting tubes. When the degeneration passes into **necrosis** the tubular epithelial cells become either turbid, or pale and homogeneous. The dropsical cells become greatly swollen, and clear spherules (so-called vacuoles) appear in their protoplasm: these are presently extruded or set free when the cell disintegrates.

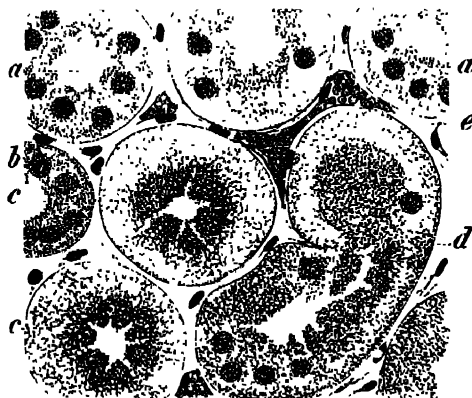


FIG. 206. NECROSIS OF THE TUBULAR EPITHELIUM IN *ICTERUS GRAVIS*.
(Hardened in Müller's fluid, stained with gentian-violet, and mounted in Canada balsam: × 300)

a normal convoluted tubule
b ascending limb of Henle's loop
c convoluted tubules with necrosed epithelium
d convoluted tubule with epithelium partly sound, and partly necrosed
e unaltered stroma, with blood-vessels

Sometimes they coalesce to a frothy-looking mass. The nuclei of the cells sooner or later disappear (Fig. 206 *c d*), often before the form of the cells themselves is lost. This loss of the nucleus is due either to a process of swelling up and solution, or to disintegration into fragments. The necrosed cells either break up *in situ*, or are first detached and then dissolve or disintegrate (Art. 533). Sometimes oil-globules may be seen in the necrosed epithelium.

When a portion of the tubular epithelium undergoes necrosis, similar changes are usually to be made out here and there in the glomerular epithelium also. Sometimes the changes are very marked. The cells swell up, are cast off (Fig. 207 e_1 e_3), lose their nuclei (*e*), and occasionally become vacuolated (e_2). Treatment of



FIG. 207. NECROSIS OF GLOMERULAR EPITHELIUM AND EXUDATION INTO THE CAPSULE OF BOWMAN IN *ICTERUS GRAVIS*.

(*Hardened in Müller's fluid, stained with gentian-violet, and mounted in Canada balsam.* × 300)

a normal capillary loop
b capsule of Bowman
c capsular epithelium
d loop denuded of epithelium
e e_1 e_2 e_3 shed and degenerate glomerular epithelium
f exudation between the epithelial cells
g granular exudation and shed cells

the sections with perosmic acid occasionally shows the necrosed epithelium to be studded with minute oil-globules. Ultimately the cells dissolve entirely, or with the exudation from the glomerular vessels form a granular coagulum (*g*). The denuded capillaries look pale and devoid of nuclei (*d*); they swell up and appear somewhat thickened. When the necrosis is total all the nuclei disappear.

The capsular epithelium undergoes necrosis much less frequently than that of the glomerulus, but cases occur in which it entirely perishes.

Necrosis of the renal epithelium appears as a primary affection

chiefly in cases where the blood-supply of a region of the kidney is for a time interrupted, and when poisonous matters are excreted through it. Bile, cantharides, chromates, potassium chlorate, have this effect, which is also met with in various infective diseases such as diphtheria, septicaemia, pyaemia, acute yellow atrophy of the liver, etc. It may be confined to a few small parts, or be spread over a number of patches of considerable extent. The affected spots are turbid, grey, and opaque.

The cells of the vascular connective tissue are much less often affected by necrosis than the epithelial cells. NAUWERCK makes out that this happens most frequently in the case of the endothelium of the capillaries and venules, the cells of which are shed and transformed into pale homogeneous or finely granular masses, sometimes studded with minute spherules, and rounded, elongated, and sausage-like in shape. This change is not however confined to the kidney, but appears simultaneously in the vessels of other organs. Necrosis of the renal connective tissue is most common after long-persistent anaemia, in septic nephritis, and in cases of uratic deposit. The latter occurs in gout; indeed the formation of homogeneous necrotic patches beset with uratic crystals or granules has been held (EBSTEIN) to be the diagnostic mark of the **gouty kidney**.

Necrosis of the renal structures may also occur idiopathically, as it is called. If the loss of tissue be not great and confined to the epithelium, repair by regeneration is possible. Greater losses, or losses involving the connective tissue, result in permanent atrophy of the parts concerned (Arts. 527, 528). Calcareous salts are occasionally deposited in the necrotic patches, but this is rare.

The presence of necrotic tissue may induce inflammation in the contiguous tissue. In other and not infrequent cases the inflammation accompanies or even precedes the necrosis; the poison or other agent, which causes necrosis in one part, acting as an irritant in another. This is exemplified in many bacterial affections of the kidney. Necrosis of the glomerular epithelium is always followed by transudation of albumen (Fig. 207 *g*), which coagulates when the section is treated with various reagents, and sometimes also during life (Art. 533).

According to FRERICHS diabetes is always associated with a 'glycogenous degeneration' of the epithelium of Henle's loops, the cells swelling up and becoming hyaline. When treated with iodine brown-stained spherules and specks become visible in the protoplasm of the cells.

References:—WEIGERT, *Virch. Arch.* vol. 72; LASSAR, *ibid.* vol. 77; MARCHAND, *ibid.*; SCHACHOWA, *Untersuch. üb. d. Nieren* Berne 1876; CORNIL, *Gaz. méd. de Paris* 18, 1879 and *Journ. de l'anat.* 1879; FRANKEL, *Zeitschr. f. klin. Med.* II; LITTEN, *ibid.* IV; KOHN, *Berl. klin. Woch.* 1882; EBSTEIN, *Die Natur u. Behandlung d. Gicht* Wiesbaden 1882, *Deut. Arch. f. klin. Med.* XXVIII; WINDLE, *Dublin Journ. med. sci.* 1883; FRERICHS, *Zeitschr. f. klin. Med.* VI (1883), *Ueber den Diabetes* Berlin 1884; LEBEDEFF, *Virch. Arch.* vol.

91; ELIASCHOFF, *ibid.* vol. 94; AUFRECHT, *Pathol. Mittheil.* II (1883); NAUWERCK, *Deutsche med. Woch.* 1884; Discussion, *Trans. Path. Soc.* XXXIV 1883; INGLESSIS, *Le rein dans le diabète* Paris 1886.

536. **Fatty degeneration** of the kidney occurs under various conditions, and affects chiefly the epithelial structures.

In the first place, cloudy swelling (Art. 534) may issue in fatty change; or the latter may be associated with epithelial necrosis (Art. 535). Fatty change however is frequently met with as an independent affection, especially in chronic anaemia or engorgement, in many forms of poisoning (as with phosphorus or arsenic), and in infective diseases such as scarlatina, yellow fever, typhus, small-pox, etc. It may affect not only the tubular but also the glomerular and capsular epithelium, and is characterised by the formation within the cells of droplets of oil of various sizes (Art. 544, Fig. 213). When the degeneration is extreme the cells may become entirely disintegrated.

Slight fatty change is not perceptible to the unaided eye, especially when the vessels are full of blood, as in renal engorgement. Where the change is more marked the parenchyma assumes a greyish-white, white, or yellow tint.

In phosphorus-poisoning and in yellow fever the fatty degeneration may reach an extreme degree without other textural change. And in like manner we may have extreme fatty change uncomplicated with other conditions, the cause of which is as yet unrecognised. This is however rare, inasmuch as sooner or later inflammation is sure to be set up. A kidney which is uniformly of an opaque white through fatty transformation (**white** or **fatty kidney**) is always either inflamed or amyloid in some degree.

The inflammatory condition is in many cases secondary to the fatty change (as in anaemia, phosphorus-poisoning, and yellow fever). In other cases it is antecedent or concomitant; so that the process is throughout inflammatory, and the fatty change is to be regarded as an accompaniment or result of the inflammation (Art. 544).

Fatty change may issue in complete recovery if the initiating cause be checked or removed, the lost epithelium being replaced by regenerative multiplication of the uninjured cells. This is especially true of non-inflammatory change, inflammatory conditions leading in general to destruction or atrophy of the tissues. It is of course immaterial whether the inflammation is primary or secondary.

Degeneration of the vascular connective tissue occurs to a serious extent only in cases where there is simultaneously a widespread degeneration of the epithelial structures; it is most marked in the inflammatory varieties. The capillaries are in general the most affected, their endothelium at times appearing crammed with oil-globules.

In the fibrous structures the connective-tissue cells are the

parts which become fatty. The droplets of oil met with in the meshes of the tissue are for the most part derived by absorption from the affected tubules.

References :—Bartels, *loc. cit.*; Weigert, *loc. cit.*; Cornil and Brault, *Journ. de l'anat.* xviii (1882), *Practitioner* xxxii (1882); Charcot, *Leçons sur les maladies du foie et des reins* Paris 1877; Johnson, *Med. chir. Trans.* xlii (1853); Whipham and others, *Trans. Path. Soc.* x, xiii, xix; Rickards, *Brit. Med. Journ.* 2, 1883.

537. **Amyloid degeneration** of the kidney often appears in what is known as the "**large white kidney**;" it may however in other cases present an appearance that has little in common with this form.

Slight degrees of the affection frequently give rise to no characteristic change. The cortex may be more or less red according to the quantity of blood it contains; but it is usually paler and softer than in health, and somewhat yellow. If the change is greater the cortex is generally pale and anaemic, with a greyish or yellowish tint, and more or less swollen. The colour is also rather spotty, numerous small white opaque patches being sprinkled over a greyish-white translucent ground. The interlobular veins, if distended with blood, may cause the cortex to be streaked with red. The glomeruli are seen as pale or reddened nodules, occasionally somewhat translucent. The medullary zone is usually streaked with red, but it is not infrequently pale. The surface of the kidney is smooth, or here and there slightly granular and shrunken.

In a third variety, where the amyloid change has reached its highest intensity, the kidney is also pale and spotted with white or yellow, but its consistence is much denser and firmer than in the second variety. On section a number of semi-translucent patches and streaks appear, looking like bits of boiled bacon, and scattered through the medulla as well as the cortex. In extreme cases these may coalesce into continuous areas. Between the soft and the hard (or lardaceous) amyloid kidney there are of course many transitional forms.

The white patches are due to fatty degeneration, which always accompanies the amyloid change, but varies much in its extent.

Simple amyloid change gives the renal tissue the semi-translucent lardaceous aspect, which is well seen in the larger continuous patches. It affects first of all the glomerular capillaries, whose walls become thickened and homogeneous (Fig. 208 *b*). At first the altered patches are scattered irregularly, but soon they coalesce so that at length the entire glomerulus is transformed into an aggregation of homogeneous flakes or blocks. When the degeneration is complete the vessels become impermeable.

After the glomeruli the parts most affected are the walls of the vasa afferentia (*i*) and interlobular arteries, and those of the vessels of the medullary zone. Lastly the change may extend over the

greater part of the venous and capillary system of the cortex, and even attack the membrana propria of the urinary tubules. These parts all become thickened, homogeneous, and translucent, and yield the familiar amyloid reactions.

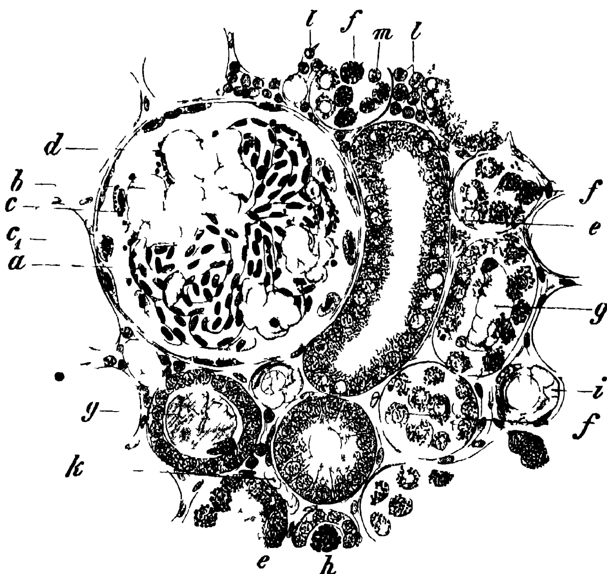


FIG. 208. AMYLOID KIDNEY WITH FATTY DEGENERATION.
(*Treated with Muller's fluid and perosmic acid* × 300)

a	normal capillary loop	g	hyaline tube-casts
b	amyloid capillary loop	h	fatty tube cast
c	fatty glomerular epithelium	i	amyloid arteriole
c_1	fatty capsular epithelium	k	amyloid capillary
d	oil-globules lying on the capillaries	l	cellular infiltration of the connective tissue
e	fatty epithelium *in situ*	m	round cells within a urinary tubule
f	loosened fatty epithelium		

The whole of the epithelial elements of the kidney—tubular, glomerular, and capsular—may simultaneously become more or less fatty (*d e f*). The extension of the fatty change is not proportionate to that of the amyloid change : it may be extreme when the latter is slight, and inversely.

The convoluted tubules are frequently the most affected. Their epithelium is not only fatty, but loosened and disintegrated (*f*). When this change is marked, and some of the glomeruli become at the same time impermeable, small patches of the renal parenchyma may atrophy and disappear, and so give rise to contractions. If these lie near the surface they appear as small cicatricial depressions.

The loose epithelial cells naturally fall into the lumen of the tubules, and may there form cylindrical masses of fatty cells or fatty detritus. Others of the tubules contain hyaline cylinders,

which are soft and transparent, or firm and waxy. The firmer kinds stain with iodine a somewhat deeper brown than the surrounding structures, but do not usually give the typical amyloid reactions.

In the meshes of the intertubular connective tissue we frequently find cellular infiltrations (*l*), a sign that a certain amount of inflammation accompanies the other changes. Sometimes too there is a certain amount of fibrous hyperplasia and induration.

We have already discussed (Arts. 57—62) the aetiology and the significance of the amyloid degeneration. As to the fatty degeneration which accompanies the amyloid change in the kidney we must assume that it is mainly the effect of the same agencies as the latter, though no doubt the disturbances of the circulation occasioned by the amyloid deposits have something to do with it. The accompanying inflammatory changes too are probably a third effect of the same causes. In support of this view it is to be noted that now and then (NAUWERCK) the presence of bacteria in the vessels of the amyloid kidney can be demonstrated.

References :—Arts. 61, 62 ; FEHR, *Die amyloide Degeneration* Berne 1867 ; GRAINGER STEWART, *Bright's diseases* Edinburgh 1871 ; LITTEN, *Berl. klin. Woch.* 1878, *Med. Times and Gaz.* 2, 1878 ; DICKINSON, *Diseases of the kidney* II London 1877 ; STRAUSS, *Soc. méd. des hôpitaux* 1881 ; CORNIL, *Practitioner* XXXII (1882), *Pathologie du rein* Paris 1884.

CHAPTER LXIX.

HAEMATOGENOUS NEPHRITIS.

538. The term **haematogenous nephritis** includes all the inflammatory affections of the kidney the exciting cause of which reaches the organ by way of the circulation.

The anatomical condition for the existence of nephritis is the presence of an inflammatory alteration of the blood-vessels. As this is incapable of direct demonstration the evidence of it appears in the presence of an inflammatory exudation.

In glandular organs an inflammatory exudation lodges either in the connective-tissue stroma, or in the lumen of the acini and ducts; in the latter case it mingles with the specific glandular secretion, whose composition is thereby altered.

The kidney is no exception to the rule. But the determination of many points in connexion with renal inflammation is rendered difficult by the fact—that the kidney normally contains a large quantity of liquid transuded from the blood-vessels, and thus inflammatory exudations entering the tubular system are frequently not at once distinguishable from non-inflammatory transudations.

Our decision as to whether for example the contents of a Bowman's capsule or a uriniferous tubule are inflammatory or not depends on their composition. Inflammatory exudations are always highly albuminous; they usually contain blood-cells, and often fibrinous coagula. The altered secretion of an inflamed kidney also contains albumen; and generally blood-cells and coagula. If then we are sometimes in doubt as to the nature of a given renal affection it is owing to the fact that a simple degeneration of the glomerular or tubular epithelium, or a transitory disturbance of the circulation, may occasion the escape of albumen from the blood into the urine. If other decisive marks are absent we may fall back on this—that the quantity of albumen in the urine in inflammatory affections of the renal vessels is greater than in simple degeneration or hyperaemia. But after all is said it must be granted that it is impossible to draw an absolutely sharp line between renal inflammations and renal degenerations.

539. Clinical authorities describe three chief types of nephritis.

The first is **acute nephritis**, distinguished by diminution in the quantity of urine, which is of high specific gravity, contains much albumen, is of acid reaction, and is dark or occasionally smoky or blood-stained in colour. The sediment contains white blood-cells, and when the urine is smoky or bloody red blood-cells, also tube-casts which are hyaline or occasionally granular and mingled with red blood-cells or their detritus, epithelial cells from the collecting tubes, turbid swollen and broken-down cells from the convoluted tubules, and sometimes concavo-convex epithelium from the glomeruli.

Scarlatina, diphtheria, croupous pneumonia, relapsing fever, septicaemia, pyaemia, typhoid, endocarditis, and articular rheumatism are frequent causes or concomitants of acute nephritis, though it also arises idiopathically. Anasarca is usually present, but not always, especially in the secondary varieties.

The usual issue of the affection is in recovery, though death may occur from uraemia. Only in rare instances does it pass into chronic indurative nephritis with hypertrophy of the heart and polyuria. More rarely still does it lead to chronic parenchymatous nephritis, and though many cases are of long duration the process does not usually end in a fatal chronic disease, but in ultimate recovery.

The clinical term acute nephritis includes a number of anatomically distinct types of renal inflammation. There is in almost all cases some disorder of the glomeruli, and this may by itself give rise to all the symptoms of acute nephritis; but in many cases the uriniferous tubules or the intertubular stroma or both are also affected, and these changes give rise to corresponding peculiarities in the anatomical aspect of the disease.

The second form recognised by physicians is **chronic parenchymatous nephritis**. Its characters are these:—onset insidious or subacute, and invariably accompanied by anasarca, which may be the first symptom attracting the patient's notice to his condition; urine highly albuminous, slightly diminished in quantity, of a turbid yellow tint, of increased specific gravity, and usually free from blood, though haemorrhagic varieties occur; in the sediment numerous tube-casts of various sizes, white blood-cells, fatty epithelial cells, granular and fatty detritus, and fat-granule cells. Red blood-cells are usually few or absent, being abundant only in the haemorrhagic forms.

Recovery is rare. As a rule after the disease has lasted for months or years death ensues from increasing dropsy, cerebral oedema, pleurisy, pericarditis, uraemia, or other cause. Sometimes however the aspect of the case changes: cardiac hypertrophy and rise of the arterial blood-pressure cause the flow of urine to increase, its specific gravity and proportion of albumen diminish,

the dropsy disappears, and the case presents the features of renal cirrhosis.

The third form is **renal cirrhosis** or **indurative nephritis.** It is characterised by the following features:—increased flow of pale slightly albuminous urine of low specific gravity; sediment containing few formed elements, pale hyaline casts, white blood-cells, and occasionally a few red blood-cells; anasarca absent; the heart hypertrophied; the fundus of the eye affected by a special form of neuro-retinitis. The onset is usually very gradual, and the first symptoms of the malady are disorders of digestion or of vision, palpitation, cardiac distress, etc. After a duration of years death ensues from such causes as cardiac failure, dropsy, cerebral haemorrhage, uraemia, purulent inflammations of serous membranes, etc.

Rarely are the essential symptoms of renal cirrhosis presented by a case commencing as an acute nephritis; such cases when they occur are usually marked by their rapid course.

Chronic parenchymatous nephritis is characterised anatomically by great degeneration of the renal epithelium: renal cirrhosis by marked changes in the connective tissue of the vascular system. The two forms are thus distinguishable anatomically as well as clinically, and the pathological anatomist may therefore accept the clinical classification. It is however to be kept in mind that the two forms are by no means antithetic; the distinction is rather one of degree than of kind. In the former affection the connective-tissue elements undergo some morbid change, in the latter there is always some epithelial degeneration. There are in fact numerous intermediate and transitional forms partaking of the characters of both.

The attempt has often been made to interpret the several forms of nephritis as stages of a single morbid process. But apart from the fact that acute nephritis does not usually pass into any of the chronic forms, there is this insuperable objection—that a given condition of the kidney in chronic nephritis may have been arrived at in several very different ways. There is no doubt at least that the mode of beginning of the disease differs in different cases. There is as little ground for the view that all forms of nephritis begin with glomerular changes, as that they all begin with epithelial degeneration or interstitial infiltration. And if the mode of beginning varies so also does the further course of the disease; we are in fact unable to say of a given advanced renal affection either how it began or what stages it has passed through. We can in general as little forecast how a given acute inflammation of the kidney would have terminated had the patient lived. We must therefore content ourselves with describing as accurately as possible the several forms that offer themselves for examination, and suggesting the possible ways in which these forms may have arisen.

The modern investigations of the affections included under the term nephritis begin with the observation of BRIGHT (*Report of medical cases selected with a view of illustrating the symptoms and cure of diseases by a reference to morbid anatomy* I London 1827) that certain cases of dropsy depended on disease of the kidney, and were distinguished by albuminous urine. BRIGHT himself described various forms of renal disease leading to albuminuria. These affections have since been included under the term **Bright's disease** (*morbus Brightii*); but the term has been variously applied by various authors—some including under it all renal affections associated with albuminuria, others excluding the simple degenerations and disorders of circulation and including only the inflammatory affections.

ROKITANSKY (*Handb. d. path. Anat.* II 1842) distinguished eight forms. FRERICHS (*Die Bright'sche Nierenkrankheit* Brunswick 1851) regarded the different forms merely as different stages of one and the same process. This process, he held, began with hyperaemia, passed on to exudation and parenchymatous degeneration, and ultimately issued in atrophy and contraction.

The works of BRIGHT and FRERICHS have given rise to a vast number of memoirs of which the following may be particularly mentioned :—CHRISTISON, *On granular degeneration of the kidnies* Edinburgh 1839; RAYER, *Traité des maladies des reins* Paris 1840; WILKS, *Cases of Bright's disease, Guy's Hosp. Reports* VIII (1853); VIRCHOW, *Virch. Arch.* vol. 4; JOHNSON, *Diseases of the kidney* London 1852, *Lectures on Bright's disease* London 1873; GULL and SUTTON, *Med. chir. Trans.* IV (1872); BEER, *Die Bindesubstanz d. menschl. Niere* Berlin 1859; FORSTER, *Handb. d. path. Anat.* 1863; DICKINSON, *Med. chir. Trans.* XLIII, XLIV (1860—61), *Pathology of Albuminuria* London 1868, *Renal and urinary affections* London 1877—85; TRAUBE, *Gesamm. Abhandl.* II (1871); KLEBS, *Handb. d. path. Anat.* Berlin 1870; GRAINGER STEWART, *Bright's diseases of the kidney* Edinburgh 1871; RINDFLEISCH, *Path. Hist.* II (New Syd. Soc.) London 1873; BARTELS, *Ziemssen's Cyclop.* XV; KELSCH, *Arch. de physiol.* 1874; GALABIN, *Bright's disease and changes in the vascular system* London 1874; MAHOMED, *Med. chir. Trans.* LVII (1874), *Lancet* 1, 1879; CORNIL and RANVIER, *Man. Path. Hist.* II London 1886; LECORCHÉ, *Traite des maladies des reins* Paris 1875; CHARCOT, *Leçons sur les maladies du foie et des reins* Paris 1877; BUHL, *Mitth. a. d. path. Inst. zu München* Stuttgart 1878; AUFRECHT, *Die diffuse Nephritis* Berlin 1879, *Cent. f. med. Wiss.* 47, 1882 and *Deutsch. Arch. f. klin. Med.* XXXII; WEIGERT, *Sammlung klin. Vorträge*, 162, 163 (1879); RIBBERT, *Nephritis u. Albuminurie* Bonn 1881; HORTOLÈS, *Étude du processus histologique des néphrites* Paris 1881; BAMBERGER, *Sammlung klin. Vorträge* 173 (1879); WAGNER, *Deutsch. Arch. f. klin. Med.* XXV, XXVII, XXVIII, *Ziemssen's Handbuch* (3rd German edition) IX Leipzig 1882; ROSENSTEIN, *Path. u. Therap. d. Nierenkrankh.* 1870; FISCHL and SCHÜTZ, *Prag. Zeitschr. f. Heilk.* III (1882); LETZERICH, *Virch. Arch.* vol. 55; LANGHANS, *ibid.* vol. 76; THOMA, *ibid.* vol. 71; SENATOR, *ibid.* vol. 73; GRAWITZ and ISRAEL, *ibid.* vol. 73; POSNER, *ibid.* vol. 79; SAMUEL, *ibid.* vol. 73; EWALD, *ibid.* vol. 71; PLATEN, *ibid.* vol. 71; EBERTH, *Zur Kenntniss bacter. Mycosen* Leipzig 1872; HOFMEIER, *Zeit. f. Geburtshilfe* III; ZIEGLER, *Deutsch. Arch. f. klin. Med.* XXV; LITTEN, *Charité-Annalen* IV, *Berl. klin. Woch.* 1878; WEISSGERBER and PERLS, *Arch. f. exp. Path.* VI; LANCEREAUX, *Dict. encyc.* Paris 1881; LEYDEN, *Zeitschr. f. klin. Med.* III; Discussion, *Trans. internat. med. congress* II London 1881; Discussion, *Congress f. innere Medicin* Wiesbaden 1882; FRIEDLÄNDER, *Arch. f. Anat. u. Physiol.* 1881, *Fortschritte d. Med.* I (1883); BRAULT, *Des formes anatomo-path. du mal de Bright, Arch. générales de méd.* 1882; CORNIL and BRAULT, *Journ. de l'anat.* XIX (1883), *Practitioner* XXVII, XXVIII, XXXII (1881—84); DUNIN, *Virch. Arch.* vol. 93; FISCHL, *Beiträge z. Histol. d. Scharlachniere, Zeitschr. f. Heilk.* IV; Discussion on Albuminuria, *Glasg. Med. Journ.* 1884; BIERMER, *Breslau. ärztl. Zeitschr.* 1, 1882; SEMMOLA, *Revue médicale française* 1883; NAUWERCK, *Beiträge zur Kenntniss des Morbus Brightii* Jena 1884 (with a critical account of various theories); SENATOR, *Albuminuria in health and disease* (New Syd. Soc.) London 1884; ROBERTS,

Urinary and renal diseases London 1885; HOLSTI, *D. Arch. f. klin. Med.* XXXVIII (1885); SAUNDBY and GREENFIELD, *Trans. Path. Soc.* XXXI.

KLEBS excludes the non-inflammatory renal degenerations from the category of Bright's disease, and identifies the latter with primary interstitial nephritis; the associated changes in the epithelium he regards as secondary. JOHNSON regards the presence or absence of epithelial degeneration and desquamation as an essential feature, and treats of nephritis as desquamative or non-desquamative, each form having its subordinate varieties. GRAINGER STEWART speaks of 'Bright's diseases', and distinguishes three forms—the inflammatory form, the amyloid form, and the cirrhotic or contracting form. Of the first he describes three stages—that of inflammatory exudation, of fatty change, and of atrophy. VIRCHOW (*Cellular Pathology* London 1860) also distinguishes three forms—parenchymatous nephritis, indurative interstitial nephritis, and amyloid degeneration. BARTELS divides Bright's disease into—acute parenchymatous, chronic parenchymatous, and interstitial nephritis. LECORCHÉ distinguishes only a parenchymatous and an interstitial form. CHARCOT on grounds partly clinical, partly anatomical, makes three—the first characterised clinically by its rapid course, scanty urine with abundant albumen, and dropsy, and anatomically by its large white kidney; the second by its chronic course, abundant urine with little albumen, absent or slight dropsy, and contracted kidney; the third form is the amyloid degeneration. WEIGERT divides Bright's disease into parenchymatous degenerations and true nephritis; the former are all acute affections; the chronic forms are but modifications of one and the same process: he deems it impossible to distinguish interstitial from parenchymatous forms, inasmuch as all forms begin with degeneration and loss of epithelium, and then pass into the stage of reactive interstitial inflammation. DICKINSON makes three classes—tubal nephritis (acute and chronic), granular degeneration with hyperplasia and contraction of the stroma, and depurative disease (or amyloid degeneration). AUFRECHT speaks of an acute, a subacute, and a chronic nephritis, and maintains that the primary change is an affection of the tubular epithelium, the vessels and the fibrous structures being affected secondarily: he describes amyloid disease as a nephritis. WAGNER considers that Bright's disease is a clinical term, implying a disease in which the urine exhibits certain morbid changes: he treats it under the four heads of (1) acute Bright's disease, (2) chronic Bright's disease, (3) contracted kidney, (4) amyloid kidney. LEYDEN defines the term Bright's disease from the clinical or physiological point of view (*Congress f. innere Med.* Wiesbaden 1882) as an affection characterised by albuminuria and dropsy, including in the term renal degenerations, pyelonephritis, amyloid change, etc. ROSENSTEIN (*ibidem*) thinks on the other hand that the term must be defined according not to clinical but to pathological and anatomical characters. CORNIL uses the term albuminous nephritis as equivalent to Bright's disease and treats the various forms under the heads of acute nephritis, parenchymatous or epithelial nephritis, and interstitial nephritis.

The above summary shows how widely authorities differ as to the content of the term Bright's disease, and as to the anatomy and pathogenesis of nephritis. We might easily carry our references further and so bring out still greater differences. This is true not only of the older authorities, but even of the most recent, the latest discussions on the subject showing clearly that on the basis of our present knowledge no reconciliation of the conflicting views is possible.

This being the case the author has thought it best in dealing with the pathological anatomy of the nephritic process to refer as little as possible to the existing literature of the subject, and to be guided mainly by the results of his own investigations. This he has done with less hesitation inasmuch as for some years he has given considerable attention to the subject and has collected an extensive series of observations on it. During the last two or three years he has had the further advantage of watching the results of a research on nephritis carried out in his presence by Dr NAUWERCK. His work

has thrown much light on the subject, and some of the figures hereafter given are taken from his admirable preparations. The experimental researches on nephritis made by GRAWITZ and ISRAEL, PONFICK, LASSAR, MARCHAND, AUFRECHT, BUCHWALD, LITTEN, and others have but slight bearing on the questions raised by the phenomena of nephritis in man. The varieties of renal degeneration set up by the injection or administration of various chemical irritants or by interruptions of the blood-supply, etc. have but distant relation to nephritis proper, and admit of useful comparison with the human affections exactly corresponding to them and with no others. Still less have the degenerations of the kidney induced by ligature of the ureter to teach us concerning the textural changes in human haematogenous nephritis. For this latter we must in the first place look to a careful anatomical investigation of the diseased human kidney.

As to the exact significance to be attached to the term Bright's disease we must leave clinical experts to decide. It is essentially a clinical term, and the pathological anatomist may for the present dispense with it.

Acute Nephritis.

540. **Acute glomerulo-nephritis.** The simplest form of acute nephritis is that in which the inflammatory changes are in the main confined to the glomeruli, the intertubular vessels being but slightly affected.

The glomeruli themselves often show no marked histological change; the presence of an albuminous exudation, which coagulates by alcohol or by heat and forms a crescentic areola around the glomerular vessels, being sometimes the only evidence that the vessels have been altered. Other glomeruli may be somewhat swollen, or partially denuded of epithelium (Fig. 209 *g h*; Fig. 213 *e*, Art. 544). In more severe cases some of the capillary loops are entirely denuded (Fig. 207 *d*, Art. 535; Fig. 209 *k*; Fig. 212 *b*, Art. 543), and the vessels look pale, denucleated, and necrotic;



FIG. 209. SECTION THROUGH GLOMERULAR CAPILLARIES IN ACUTE NEPHRITIS FOLLOWING DIPHTHERIA: AFTER *NAUWERCK*.

(*The glomerulus lies near the surface of the kidney: section hardened in alcohol, stained with alum-carmine and eosin, and mounted in Canada balsam:* × 450)

- *a* nucleus in capillary-wall
- *b* swollen and loosened endothelial cell
- *c d* endothelial cells with multiple nuclei
- *e* glomerular epithelium
- *f* disintegrating glomerular epithelium
- *g* nucleus of a detached epithelial cell
- *h* vesicular (degenerate) epithelial cell
- *i* coagulated albumen
- *k* denuded capillary-wall

or they are transformed into homogeneous spherules with few or many nuclei, larger than the normal glomeruli and impermeable by the blood or by artificial injections. According to FRIEDLANDER the latter is the form most frequent in post-scarlatinal nephritis, and it may extend over a great part of the kidney. It would appear to be due to a hyaline swelling (Art. 63) of the vessel-walls themselves.

Some of the capillaries appear to contain an excess of white blood-corpuscles and it is possible that this may occasionally give rise to thrombosis (RIBBERT). According to LANGHANS and NAUWERCK the endothelial cells of the capillary loops become swollen (Fig 209 *a*), proliferous, loosened (*b*), and degenerate (*d*), the epithelial cells of the glomeruli (*h k*) also undergoing desquamation. Haemorrhagic exudation is very common, the capsule of the glomerulus then becoming tightly distended with blood (Fig. 212 *f*, Art 544)

The tubular epithelium may be altogether unaltered. In other instances single cells may appear degenerate, turbid, fatty, or necrotic, or they may be loosened and disintegrated. Hyaline casts occupy the lumen of some of the tubules

The intertubular connective tissue is in general entirely unaffected; now and then it appears somewhat swollen from inflammatory oedema, or contains a few scattered patches of cellular infiltration.

The naked-eye appearance of the kidney is not usually altered to any sensible extent. Only when there is great hyaline thickening of the glomerular capillaries do the glomeruli become noticeable by their paleness and increased size (FRIEDLANDER).

Glomerulo-nephritis is not a specific disease, as it can be produced by a variety of causes According to KLEBS, FRIEDLANDER, CORNIL, KLEIN, etc. it is specially apt to follow upon scarlatina. It may also accompany pyaemia, septicaemia, diphtheria, relapsing fever, erysipelas, carbuncle, etc, or arise idiopathically, that is without any antecedent infective disease. It obviously is due to the action of deleterious substances reaching the glomerular vessels by way of the circulation, and damaging the vessels in the process of excretion through their walls. It thus stands aetiologically in close relation with the forms of degeneration described in Arts. 534, 535, and indeed it is difficult or impossible to draw a sharp line separating the histological appearances in the two groups.

Glomerulo-nephritis may cause death by suppression of the urinary secretion. In other cases it issues in recovery, or in chronic change.

References :—KLEBS, *Handb. d path. Anat.* I; KELSCH, *Arch. de physiologie* 1874 ; KLEIN, *Reports to Med. Off. of Privy Council* 1876 ; LANGHANS, *Virch. Arch.* vols. 76, 99 ; HORTOLÈS, *Étude d. proc. histol. des néphrites* Paris 1881 ; LEECH, *Brit. Med. Journ.* 1, 1881 ; GREENFIELD, *Atlas of Pathology* (New

Syd. Soc.) London 1879; RIBBERT, *Nephritis u. Albuminurie* Bonn 1881; COHNHEIM, *Allg. Path.* II 1882; FRIEDLÄNDER, *Fortschritte d. Med.* I (1883); CORNIL, *Practitioner* XXVIII, XXXII (1882—84); CORNIL and BRAULT, *Pathologie du rein* Paris 1884; B. C. WALLER, *Journ. of Anat. and Physiol.* XIV 1879; NAUWERCK, *Beitr. z. Kennt. d. Morb. Brightii* Jena 1884.

541. **Acute diffuse nephritis** with sero-fibrinous exudation, or as we may call it acute inflammatory oedema of the kidney, gives rise to more or less swelling of the organ, in some cases so extreme that it attains a length of 22 to 25 centimetres. The capsule is easily stripped off, the surface smooth, the tint grey or greyish-red speckled with yellowish-red. On section the cortex and medulla appear swollen and sodden, usually pale-grey, or greyish-yellow, and occasionally streaked or speckled with red. The whole organ is soft, especially so when the swelling is great.

The swelling is due mainly to the accumulation of liquid in the intertubular connective tissue of the cortex (Fig. 210), and to some extent of the medulla.

The stroma is greatly thickened and contains a liquid which in recent preparations, more commonly however in hardened ones, is mingled with threads and granules of fibrin (*a*). The vessels may be compressed by the liquid, but sometimes at least in places appear distended with blood (*b*).

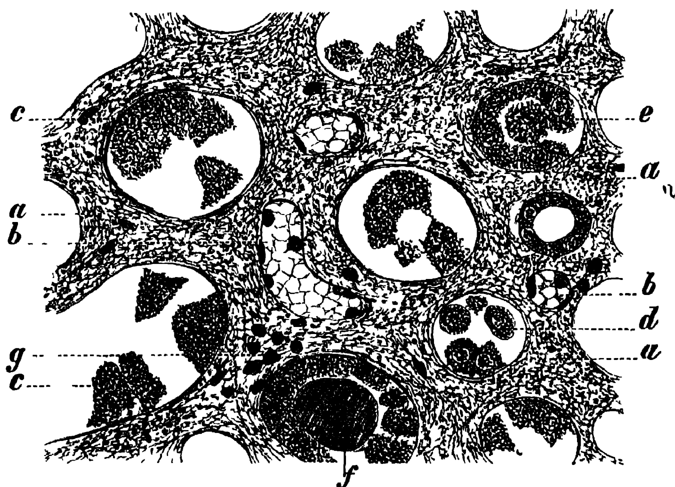


FIG. 210. DIFFUSE NEPHRITIS WITH SERO-FIBRINOUS EXUDATION.

(*Section treated with perosmic acid and mounted in glycerine:* × 350)

a stroma much thickened and beset with fibrinous threads and granules and with oil-globules
b capillaries
c epithelium of the convoluted tubules, partly turbid, partly fatty and desquamating
d shed epithelium in a Henle's loop
e granular and fatty detritus in a Henle's loop, whose epithelium is turbid but remains *in situ*
f hyaline cast
g extravasated leucocytes

The exudation contains few cells, though it is not unusual to find scattered patches of cellular infiltration (*g*). When the condition is no longer quite recent the intertubular exudation contains oil-globules.

The glomeruli are for the most part not perceptibly altered, though when treated with alcohol traces of coagulable exudation can be made out within their capsules. In some of the glomeruli moreover there is slight swelling and desquamation of the epithelium.

The tubular epithelium of the cortex and medulla is everywhere more or less swollen and loosened (*c*), in many places it is actually detached (*d*). Sooner or later fatty degeneration and disintegration of the epithelium becomes apparent.

The tubules are at first empty, but presently they are filled with hyaline casts (*f*), or with granular and fatty epithelial detritus (*e*).

The slighter forms of inflammatory oedema accompany the various infective diseases, such as typhoid fever, and give rise to some swelling and considerable dropsical saturation of the kidney. The more intense forms are seldom met with: they are most common in affections of the nature of pyaemia.

The drawing in Fig. 210 was made from the kidney of a patient who died on the tenth day of an acute febrile attack. The disorder was obviously of an infective nature, for the renal inflammation was accompanied by enormous swelling of the spleen, with purulent inflammation in the mediastinum, and later on with purulent pleurisy.

542. **Acute disseminated interstitial nephritis** is the most common form of acute renal inflammation. The kidney is swollen but little or not at all, and at first the section shows no discoloration whatsoever. Only when the interstitial changes are accompanied by marked degenerative changes do spots and patches of grey or (in fatty degeneration) white make their appearance. Haemorrhage is frequently an early symptom, and gives rise to small punctiform dark-red spots.

The diagnosis of this form of nephritis can be made with certainty only by means of the microscope.

The cellular infiltration (Fig. 211 *m*) first makes its appearance around the stellate veins (*g*) and the interlobular veins (*h*), and is usually so marked that in stained sections the affected patches can be seen under very low magnifying powers. These patches are usually most abundant in the outer zone of the cortex, and in the boundary zone between the cortex and medulla; the middle parts of the cortex being seldom much affected. The glomeruli which lie within the region of the inflamed veins may be surrounded with infiltrated cells, the latter often accumulating in a dense mass round the glomerular capsule. The connective tissue not lying within this region may be entirely unaffected, though cases occur in which other capillary regions, especially those around the

glomeruli (Fig. 213, Art. 544 and Fig. 212, Art. 543), show signs of more or less extensive cellular infiltration.

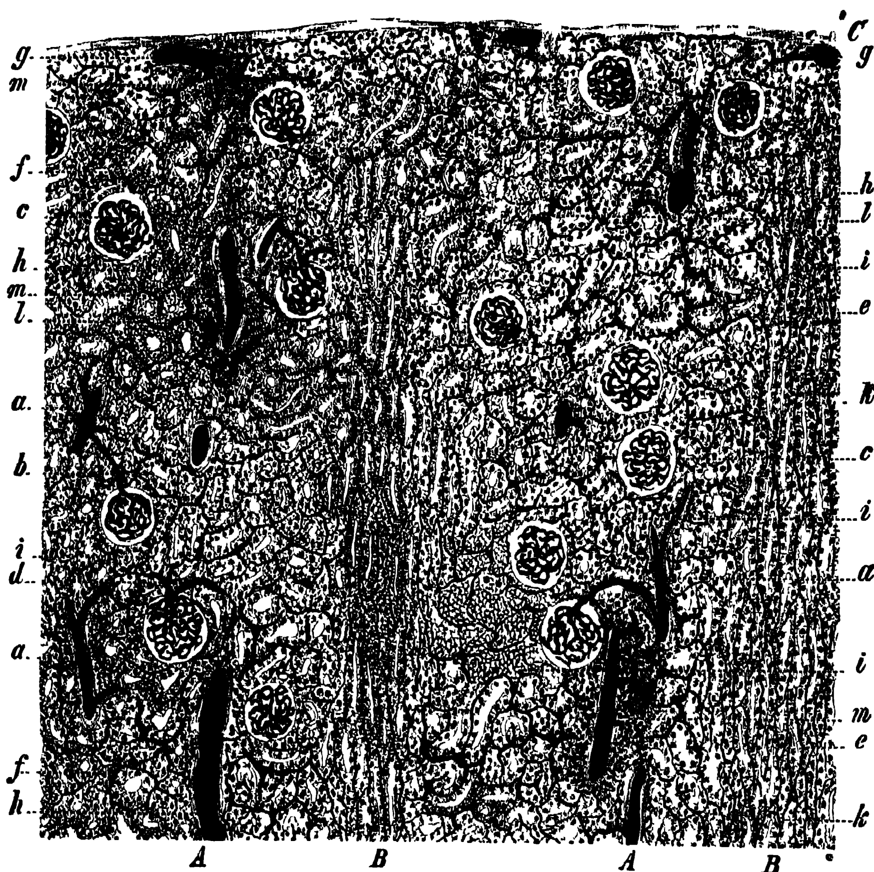


FIG. 211. OUTER HALF OF THE CORTEX IN RECENT ACUTE DISSEMINATED (INTERSTITIAL) NEPHRITIS.

(*Injected with Prussian blue and stained with alum-carmine:* × 32)

A labyrinth *B* medullary rays *C* ca

a interlobular artery
b vas afferens
c glomerulus
d vas efferens
e capillaries of the medullary rays
f capillaries of the labyrinth
g stellate veins
h interlobular veins
i convoluted tubules
k straight tubules (Henle's loops and collecting tubes)
l degenerate convoluted tubules
m cellular infiltration around the veins

The tubular epithelium may be altogether normal. Even in the centre of the inflamed region the cells occasionally remain unchanged or at most become a little cloudy, their form being retained and their nuclei continuing to stain well. NAUWERCK has observed this condition in the nephritis accompanying infective

pneumonia. In other cases the epithelium is in parts more obviously affected by the inflammatory process, and cloudy swelling with a tendency to necrosis is observed, especially in the convoluted tubules (Fig. 211 *l*). According to NAUWERCK this occurs chiefly in cases of diphtheria. The affected epithelial cells sooner or later lose their nuclei.

The degeneration and necrosis of the epithelium may either be confined to the inflamed region, or may extend beyond it. It is worthy of remark that in certain conditions the epithelium in the inflamed region may be little if at all altered, while in other parts epithelial necrosis has set in. Frequently we find that the cells of the collecting tubes are the most altered, being turbid or disintegrated into granular detritus.

The glomeruli themselves are as a rule but little affected, except in those cases which tend to issue in suppuration (Art. 543). Sometimes a few of them are partially denuded of their epithelium. Cases also occur in which at an early stage of the inflammation the epithelia of some of the capillary loops become necrosed and denucleated (Fig. 207, Art. 535), and fall away from their attachments. The capsules of some glomeruli also contain an exudation which coagulates with alcohol into a granular mass, and contains the desquamated and degenerate glomerular epithelium in the form of transparent vesicular spherules. When haemorrhage takes place, many of the capsules contain blood, which closely surrounds the vascular loops (Fig. 213, Art. 544) and passes down into the corresponding tubules. Varieties of nephritis are met with in which these haemorrhages are from the outset numerous and abundant, so much so that they may throw the interstitial changes quite into the background.

In the lumen of the tubules, especially in the loops of Henle, are formed hyaline casts, sometimes enclosing a few scattered nuclei. The tubules bordering on the patches of cellular infiltration also contain leucocytes, which have traversed the membrana propria and lie either within the tubules or in their secreting epithelium.

Disseminated interstitial nephritis may coexist with inflammatory oedema. The kidney is then more or less swollen, and mottled with red and grey. This condition is met with in connexion with various infective diseases, more especially in pneumonia and erysipelas (NAUWERCK, MOMMSEN); and also in scarlatina, diphtheria, pyaemia, and relapsing fever (PONFICK). It may also occur without any antecedent general infection of the system. It issues in recovery, or in localised induration and atrophy, or in suppuration.

RIBBERT maintains that every interstitial nephritis begins in an inflammatory change of the glomeruli. WEIGERT thinks all forms of nephritis begin in epithelial degeneration. Both views are one-sided and apply only to a limited number of cases; they relegate the essential part of the process to

place. Nephritis may begin in many different ways, and no single scheme can be laid down to which all cases shall conform.

References on nephritis following pneumonia :—WAGNER, *Deut. Arch. f. klin. Med.* XXV ; MOMMSEN, *Deutsch. med. Woch.* 1879 ; NAUWERCK, *loc. cit.* ; JÜRGENSEN, *Croupose Pneumonie* Tubingen 1883 ; FRIEDLANDER, *Fortschritte d. Med.* II 1884 ; DICKINSON, *Renal and urinary affections* III London 1885.

References on nephritis after diphtheria, scarlatina, etc :—BOUCHARD, *Rev. de méd.* 1881 ; CAPITAIN and CHARRIN, *ibid.* ; GAUCHER, *Lancet* 1, 1881 ; CORNIL, *Journ. de l'anat.* 1879, *Practitioner* XXVIII, XXXII (1882—84) ; EBERTH, *Virch. Arch.* vol. 57, *Zur Kenntniss bacter. Mycosen* Leipzig 1872 ; JACOBI, *Gerhardt's Handb. d. Kinderkrankh.* II ; KANNENBERG, *Zeitschr. f. klin. Med.* I ; KLEBS, *Handb. d. path. Anat.* ; KLEIN, *Trans. Path. Soc.* XXVIII (1877) ; LÉPINE, *Revue mensuelle* 1880 ; LETZERICH, *Virch. Arch.* vols. 47, 52, 55, 61 ; LEYDEN, *Zeitsch. f. klin. Med.* III ; LITTEN, *ibid* IV ; MARKWALD, *Ueber die Nierenaffection bei acuten Infectionskrankh.* In. Diss. Konigsberg 1878 ; OERTEL, *Ziemssen's Cyclop.* II ; SENATOR, *Virch. Arch.* vol. 56, *Die Albuminurie im gesund. u. krank. Zustande* Berlin 1882, trans. by SMITH (New Syd. Soc.) London 1884 ; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* IV ; UNRUH, *Jahrb. f. Heilk.* XVII (1881) ; P. FURBRINGER, *Virch. Arch* vol. 91 ; NAUWERCK, *Die Nephritis* Jena 1883 ; FISCHL, *Beitrage z. Histologie d. Scharlachniere, Zeitsch. f. Heilk.* 1883 ; LEICHTENSTERN, *Deutsche med. Woch* 1881 ; BABES, *Arch. de physiol.* II (1883) ; FRIEDLANDER, *Fortschritte d. Med.* I (1883), Art. 540.

ATKINSON (*Amer. Journ. med sciences* 1884) gives a good account (with references) of nephritis from malarial poisoning.

543. **Disseminated suppurative nephritis.** When a simple disseminated nephritis issues in suppuration, there are formed in various parts of the kidney, especially in the cortex but not infrequently in the medulla also, a number of rounded or linear patches of whitish pus-like matter usually surrounded by a zone of hyperaemia. In other respects the kidney may be almost normal, though there is frequently a certain amount of swelling (from inflammatory oedema) and some grey and red mottling (from disorder of the circulation).

The smallest patches (not larger than a millet-seed) are due to a steadily increasing extravasation of leucocytes, which accumulate either round the venules or round the capsules of the glomeruli.

Suppurative inflammation of the kidney is no doubt in general a result of bacterial invasion. When the micro-organisms settle within the capillary loops of the glomeruli (Fig. 212 *a*) they first block up the lumina of the vessels, then induce necrosis of the glomerular epithelium (*b*), and finally necrosis of the glomerulus itself. An inflammatory reaction is thereupon set up around the glomerulus, the first effect of which is an accumulation of extravasated leucocytes in the surrounding connective tissue (*d*). There is also usually a certain amount of exudation from the intertubular venules (*f*). The epithelium within the affected region as a rule degenerates rapidly (*g h*). Part breaks up into granular detritus, part becomes necrotic and denucleated, and desquamates. The extravasated leucocytes penetrate the tubules (*i*), and in a short time the entire region is thickly infiltrated with them. By and by not only the epithelium but the connective tissue breaks down,

and the infiltration becomes an **abscess**. The size of the abscess depends of course on the extent of the infiltration.

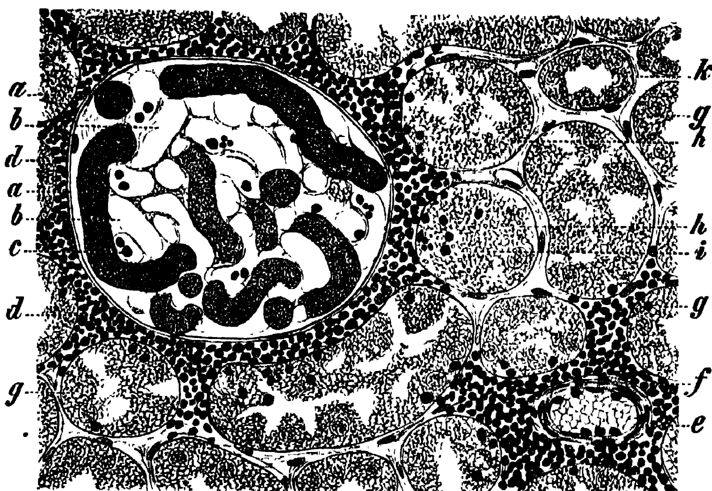


FIG. 212. DISSEMINATED SUPPURATIVE NEPHRITIS.

(*Section stained with gentian-violet and mounted in Canada balsam:* ×200)

a capillary loop filled with micrococci
b empty denucleated capillary
c leucocytes in the capillaries
d cellular infiltration around the capsule
e venule
f cellular infiltration around the venule
g convoluted tubule, with epithelium partly cloudy, partly denucleated and degenerate
h convoluted tubule with granular detritus
i leucocytes within the tubules
l limb of Henle's loop

This form of inflammation may result in the breaking down of a large part or even the whole of the kidney, so that at length nothing remains but a sac filled with pus. The latter is however not a common result of the affection now considered; it occurs much more frequently as a sequel of pyelonephritis (Art. 554).

Wide-spread suppuration of the renal tissue gives rise to catarrhal, purulent, or even diphtheritic inflammation of the pelvis of the kidney: and not infrequently abscesses are formed in the surrounding subperitoneal tissue (**perinephritic abscess**).

Suppurative nephritis (not due to pyelonephritis) occurs most frequently in connexion with ulcerative endocarditis and with traumatic pyaemia. It may however be associated with a great variety of diseases, such for instance as dysentery, ulcerative phthisis, and actinomycosis (ISRAEL, *Virch. Arch.* vol. 74). The abscesses are usually punctiform or miliary; large abscesses are rare.

Suppurative nephritis is not infrequently combined with embolic obstruction of the renal arteries, leading to the formation of infarcts.

According to LITTEN (*Zeitschr. f. klin. Med.* IV) there are some forms of acute nephritis in which large numbers of micrococci are diffused throughout

the whole of the kidney, filli g up many of the tubules and Bowman's capsules. AUFRECHT reports imilar cases (*Pathologische Mittheilungen* I 1881). LETZERICH (*loc. cit.*) affirms that in diphtheria masses of micrococci may accumulate to such an extent in the circulatory and secretory channels that the urinary function is gravely interfered with.

ZIEGLER has never been able to discover such extensive accumulations of bacteria in the kidney, even in cases of diphtheria. The suspicion arises that some other appearance has been mistaken for colonies of micrococci. Treatment of the sections with alkalies and alcohol is not sufficient to determine with certainty the presence of these organisms.

BABES (*Arch. de physiol.* II 1883) has recently described various forms of bacteria discovered by him in the renal blood-vessels in certain forms of nephritis accompanying pyaemic and septicaemic infection, scarlatina, articular rheumatism, yellow fever, etc. In connexion with the latter he found chaplets of two to six diplococci, and suggests that they may be the exciting cause of the disease STEVEN (*Glasgow Med. Journ.* 1884) discusses the suppurative affections of the kidney in a clear and able manner.

Chronic Parenchymatous Nephritis.

544. The inflammations of the kidney comprehended under the term **chronic parenchymatous nephritis** are all characterised by persistent inflammatory exudation from the blood-vessels into the renal tissue, accompanied by marked alteration of the epithelial structures. The persistent exudation takes place partly from the glomeruli and partly from the intertubular capillaries and venules.

The intertubular exudation saturates the renal tissues with inflammatory lymph, varying in quantity at different stages of the process and in different cases.

This inflammatory oedema is always accompanied by a more or less extensive cellular infiltration (Fig. 213 *q r*), which is often remarkably dense around the subcortical and interlobular venules (*q*), often also well-marked in the neighbourhood of the intertubular capillaries (*r*) and here and there in exceptional amount round a few of the glomeruli. The extravasated leucocytes (*q*) and the liquid exudation may penetrate directly into the tubules, and the leucocytes gathered around the Bowman's capsules may in like manner penetrate them. Intertubular venous haemorrhages are occasionally observed, and when the tubules are at the same time ruptured blood may enter these directly (NAUWERCK).

The vessels of certain of the glomeruli permit the escape of albuminous urine, which even during life may coagulate into a granular or homogeneous mass within the capsules. More commonly however coagulation takes place only within the tubules (especially in the loops of Henle), giving rise to the familiar hyaline casts or cylinders.

The glomerular capillaries frequently permit the escape of white (*e*) and red (*f*) blood-cells. The former often accumulate in great quantity in the capillary loops (*b*) before escaping, but they do not usually escape in large numbers into the lumen of the capsule. Comparatively few of the red blood-cells (*e*) escape into the

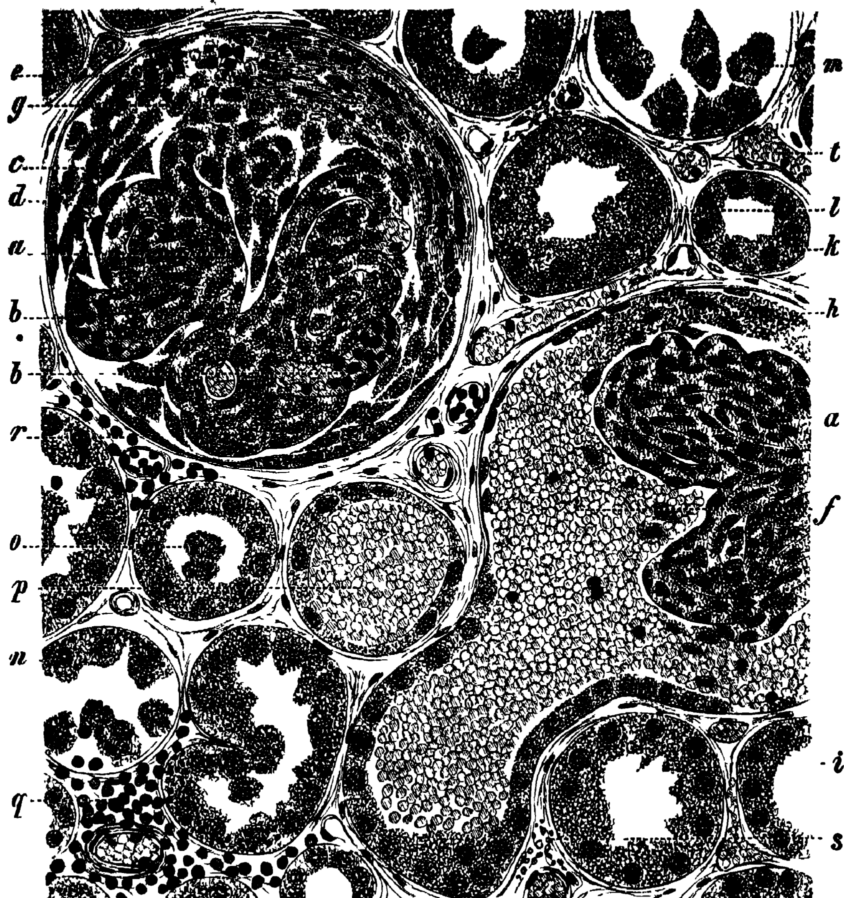


FIG. 213. CHRONIC HAEMORRHAGIC (PARENCHYMATOUS) NEPHRITIS.

(*Section hardened in Müller's fluid, stained with alum-carmine, and mounted in Canada balsam: the fatty change represented is taken from another preparation treated with perosmic acid:* × 300)

a normal capillary loop
b capillary filled with white blood-cells
c desquamated glomerular epithelium
d capsular epithelium
e exudation consisting of red and white blood-cells and granular matter
f haemorrhage into a capsule and tubule
g granular stratified exudation, containing nuclei of desquamated glomerular epithelium
h disintegrated blood containing desquamated glomerular epithelium
i convoluted tubule
k limb of Henle's loop
l tubule with pigmented and fatty epithelium
m pigmented and desquamated epithelium
n fatty cells, some of them desquamated
o loose fatty epithelial cells in the lumen of a normal tubule
p tubule filled with blood
q r cellular infiltration around venules and capillaries
s pigment-granules in stroma
t capillaries filled with blood

lumen of the capsules, though not infrequently larger extravasations are observed in which the capsules and their tubules appear widely distended with blood (*f p*).

In many cases the glomerular epithelium looks perfectly normal, but it is more common to find it somewhat swollen, the individual cells standing out clearly from the contours of the capillaries. Multiplication and desquamation usually set in, and epithelial cells are seen in greater or less numbers lying loose within the capsules (*c*). These may be washed out unchanged into the tubules, but at times they accumulate in quantity within the capsule, surrounding the glomerular vessels in successive strata (*c*) and separating or compressing the loops by their intrusion. Frequently too the cells break down or dissolve in the liquid escaping from the glomerular vessels, and homogeneous or granular coagula (*g h*) are thus formed, which more or less completely ensheath the glomerulus. The nuclei enclosed in these coagula often persist for a long time, and occasionally give them the appearance of intracapsular new-formations of connective tissue.

In addition to the swelling and desquamation of the epithelium we often remark a certain amount of fatty change, which gives the cells the look of being powdered or sprinkled with minute globules.

The glomerular capillaries appear for the most part unaltered, though all the changes described in Art. 540 may occasionally be observed.

The capsular epithelium (*d*) is as a rule far less altered than the glomerular, though it too may in certain cases become swollen, break up, and desquamate. It may also undergo fatty degeneration.

The tubular epithelium always shows more or less marked signs of cloudy swelling, fatty degeneration, desquamation, and disintegration. The most striking of these changes, the fatty degeneration (*l m n*), is distinguished by the presence of droplets and globules of oil within the cells, varying in size and number according to the degree of degeneration. The fatty cells (*m o*) are the most apt to be shed, though this happens also in the case of the swollen and cloudy cells. These desquamated cells dissolve *in situ* or are carried into remoter parts of the tubules, where they may coalesce into hyaline cylinders

The degenerative changes affect chiefly the convoluted tubules, though they are not entirely absent in the loops and collecting tubes. In the latter especially there may be very marked desquamation of the epithelium.

When considerable haemorrhages have taken place in the glomeruli the corresponding tubules are distended with blood, their epithelium appearing compressed and flattened (*p*). The blood presently disintegrates, forming granules and flakes of pigment: these are usually taken up by the epithelial cells (*l m*), part also appearing in the fibrous stroma (*s*) whither they are carried by the absorbents (Art. 530).

In many cases it is difficult to make out definitely in what way a chronic parenchymatous nephritis has begun. In other cases it is clearly the sequel of an acute affection. So far as microscopical investigation indicates it is possible that all the varieties of acute nephritis above described, except the suppurative form, may occasionally terminate in the chronic parenchymatous form. Moreover the various degenerative processes described in Arts. 534—537 may be combined with secondary inflammatory changes, and so give rise to the morbid appearances of chronic nephritis.

VIRCHOW, FORSTER, LANGHANS, and FRIEDLANDER describe in certain cases of nephritis a multiplication of the nuclei of the glomerular capillaries, which may at times become very considerable. NAUWERCK has confirmed this by showing that the endothelial cells of the capillaries swell up and multiply (Fig. 209, Art. 540).

LITTEN (*Charité-Annalen* IV) states that in the nephritis following scarlatina and relapsing fever concentrically stratified connective tissue is rapidly formed within Bowman's capsules. According to the account in the text this would appear to be, not new connective tissue, but stratified fibrin enclosing nuclei (Fig. 213 *g*).

545. The textural changes just described pass through various developmental stages, and thus in any given case one or another of them may be the most prominent. We may therefore distinguish certain anatomically distinct forms of chronic parenchymatous nephritis, depending on the stage of the process reached at the time the kidney is examined.

In the first form the connective tissue is but slightly altered (being simply infiltrated) while the epithelium of the tubules and in part of the glomeruli is highly fatty. This form is best described as the **inflamed fatty kidney**, or the kidney of fatty parenchymatous nephritis. The kidney is moderately swollen and soft, the cortex pale-grey and beset with numerous white opaque spots and streaks. The number and magnitude of these fatty patches depends on the degree of degeneration. They may be confined to the outer or to the inner zone of the cortex. The medulla is usually more or less reddened, often indeed cyanotic. If the cortical veins are full they show as red streaks, and the stellate veins show on the pale subcapsular surface as deep-red star-shaped blotches.

In a certain sense the **large mottled kidney** forms an antithesis to the fatty kidney. It is swollen, often considerably, and its surface is mottled with grey and red. On section the cortex looks broadened, moist, soft, and streaked with grey and greyish-red; the medulla is hyperaemic. Corresponding to its external appearance we find the tissue of the kidney in a condition of inflammatory oedema, the intertubular septa being in many places infiltrated with small cells. The glomerular epithelium is here and there swollen and desquamated, and in many of the tubules the epithelial cells are likewise cloudy, swollen, and

desquamated. The fatty change is only moderately developed, the amount of fat present not sufficing to whiten the parenchyma.

When the kidney is much infiltrated and at the same time fatty, it is enlarged and the cortex is mottled with white patches; in extreme fatty change it may be all but uniformly white. This is the so-called **large white kidney**.

The differences between the three forms being rather differences of degree than of kind, there are naturally many intermediate varieties.

The external naked-eye appearance of the kidney depends greatly on the amount of blood it contains at the time of examination. Thus when the parenchyma looks red we must not at once conclude that there is no fatty degeneration, for when the latter is slight it may be quite disguised by the presence of hyperaemia. Conversely, mere paleness of the tissue is by no means a certain index of fatty change.

Haemorrhage may accompany all forms of nephritis, but there is one particular form in which the haemorrhage amounts to a characteristic; the cortex chiefly, the other parts in a less degree, being studded with red and brown patches of extravasation. This form is therefore described as **chronic haemorrhagic nephritis** (Fig. 213). The parenchyma may be altered in various ways; the most common change is a considerable degree of fatty degeneration with much infiltration of the fibrous stroma. The kidney is thus as a rule swollen and speckled with white, or almost uniformly white. There is usually much desquamation of the glomerular epithelium.

When the most marked character in a case of chronic nephritis is the morbid change in the glomerular epithelium, we might fitly describe it as **chronic glomerulo-nephritis**. When the accompanying degeneration of the tubular epithelium is slight the kidney may appear but very little altered, even though death has taken place from failure of the renal function; in such cases microscopic examination alone reveals the true character of the disease. The changes in the glomeruli are the same as those described in Arts. 544 and 540. In marked cases many of the glomeruli are obliterated.

546. **Terminations of chronic parenchymatous nephritis.** This disease not infrequently passes through the stages indicated in Arts. 544 and 545 and terminates in fatal suppression of the urinary function. In cases that are not speedily fatal the changes above described become more and more marked: which particular one of these changes is the most prominent depends on the individual peculiarities of the case.

The **fatty change** is not rarely the most extensive, the kidney becoming more and more of an unmixed white colour as the greyish or reddish regions of fairly sound tissue diminish or disappear; the latter may at last be confined to the parts about the medullary rays. In such cases not only does the renal epi-

thelium become fatty and perish, but oil-globules begin to appear in the walls of the glomerular and intertubular capillaries.

Often too the advancing fatty degeneration is accompanied by increased **cellular infiltration** of the connective tissue, so that the intertubular stroma becomes transformed into a series of swollen cellular columns.

At an early stage **atrophy of the secreting structures** begins in the regions most affected. The tubular epithelium may in consequence of the degenerative changes be lost altogether, the denuded tubules becoming therefore collapsed and functionless. This is however by no means invariably the case, for it frequently happens that in the absence of other complications the fatty and desquamated cells are replaced by the regenerative multiplication of the remaining ones. Destruction of the glomeruli is a more serious danger, for it involves not only the suppression of the urinary secretion but also the partial interruption of the intertubular circulation. The glomeruli may be rendered functionless by an excessive accumulation of loose epithelium and exuded liquid within their capsules, leading to compression of the capillaries. More commonly however the injury is primary, and due to hyaline swelling of the capillary-walls and in part to thrombosis of their channels. The epithelium always perishes, partly by desquamation, partly by fatty degeneration and disintegration Sometimes a certain amount of fibrous hyperplasia occurs in the neighbourhood of the obliterated glomeruli, and the capsules thus appear abnormally thickened.

These localised atrophic changes in the secreting structures are sooner or later followed by **cicatricial contractions** of the external surface. They are seldom quite absent in the large white kidney, and in some cases are so numerous as to give the organ a granulated appearance while its volume becomes less than normal. This is of course possible only in cases of long standing, in which the changes in the parenchyma have spread so gradually that its functions have at no time been interrupted. Such cases both in their clinical course and histological characters approach those which we class under the head of renal cirrhosis or indurative nephritis with contraction.

Chronic Indurative Nephritis.

547. **Chronic indurative nephritis** or **renal cirrhosis** is distinguished anatomically by the fact—that the inflammatory process issues in hyperplasia of the renal connective tissue, and consequent induration or cirrhosis of the parenchyma.

In chronic parenchymatous nephritis there is a certain amount of fibrous overgrowth, but this is of altogether minor importance in comparison with the other results of the inflammatory process. In indurative nephritis on the other hand it is

this fibrous overgrowth and the resulting cirrhosis which is the essential characteristic of the affection.

The disease sometimes commences acutely, but its onset is usually very gradual and insidious. In either case the appearance in the stroma of small patches of cellular infiltration is the most important of the initial changes. This infiltration is moreover always accompanied by degeneration of the epithelium, though the extent and intensity of this varies much in different cases, a fact which in the main explains the diverse clinical phenomena exhibited in connexion with the onset of the disease.

In like manner there are differences in the amount of inflammatory oedema accompanying the infiltration, and corresponding differences in the extent to which the kidney is swollen.

When the interstitial hyperplasia has continued for some weeks or months cicatricial patches appear, and as they contract give rise to depressions and puckerings of the outer surface of the kidney. These contractions are more or less numerous and extensive according to the extent of the original infiltration. The kidney is either anaemic and pale-grey in tint, or hyperaemic when it appears greyish or brownish red; its size may be normal or increased or diminished; at a later stage it is harder, tougher, and denser than in health.

The cortex is always thinned at the site of the cicatrices; elsewhere its thickness may be normal or even increased, but it is never very much increased. The cortex on section has the same tint as the surface. The pale white patches of fatty degeneration may be entirely absent, though not infrequently they may be detected in varying number within the cortical zone. The medullary zone is usually redder than is normal.

The connective tissue is hardened and overgrown not merely within the cicatrices but also at various points in the deeper layers of the cortex: the secreting structures are atrophied (Fig. 214).

The indurated patches lie chiefly in the neighbourhood of the small veins, though they may be distributed irregularly throughout the region of the labyrinth.

The first stage of the indurative change is the appearance of the disseminated cellular infiltration (*l*) of the stroma. Then the intertubular tissue (*k*) becomes more or less notably increased and fibrous: it often becomes thickly beset with small round-cells, or at least the nuclei are much more numerous than usual.

The capsules of the glomeruli in the affected region are in general considerably thickened, and appear to be made up of nucleated fibrous tissue arranged in concentric layers (*a*). It is however to be noted that the amount of thickening varies greatly: in some cases it is enormous, in others very slight. The latter is observed in instances where the infiltration is mainly around the small veins, the former where it is more uniformly diffused over the whole of the labyrinth.

The tunica adventitia of the blood-vessels (*n o*) is usually more or less thickened. Sometimes the thickening extends to the inner coats also, and leads to obstruction of the vessel. A certain

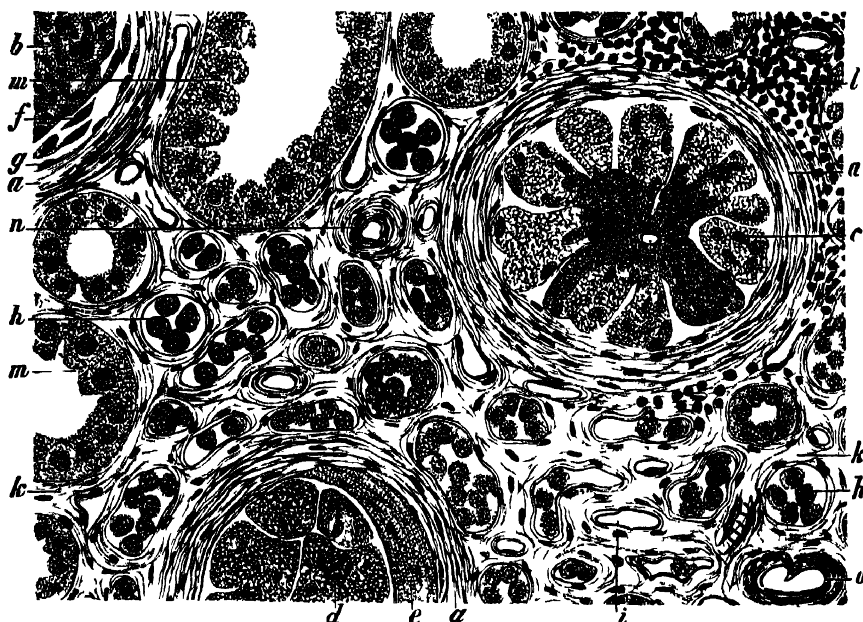


FIG. 214. INFLAMMATORY INDURATION AND ATROPHY OF THE RENAL TISSUE.
(*Section treated with alcohol and alum-carmine, and mounted in Canada balsam:* × 250)

a capsule of Bowman thickened and fibrous
b normal glomerulus
c glomerulus with vessels partly obstructed and hyaline, the epithelium being nearly all destroyed
d obliterated glomerulus
e nucleated coagulum composed of fibrinous exudation and shed epithelium
f glomerular epithelium loosened and shed
g capsular epithelium
h collapsed tubule with atrophied epithelium
i collapsed and denuded tubule
k hyperplastic fibrous stroma
l cellular infiltration
m normal tubule somewhat dilated
n vas afferens
small vein

number of the capillaries always become impermeable as the change progresses.

The glomerular epithelium in recent cases is seen to be swollen or loosened and desquamated (*f*), though this change is seldom so marked as in the forms of nephritis already described: it is also rare for the capsular epithelial cells to show signs of any great degree of multiplication or of desquamation. When there is much thickening of the capsule, or much disturbance of the circulation through obstruction of the capillaries or narrowing of the vasa afferentia, the glomeruli begin to atrophy. The capillary

loops lose their epithelium (*c*), and are transformed into pale hyaline or finely-granular denucleated (*d*) structures, which are impermeable by the blood or by artificial injections.

During the progress of the disease the glomeruli excrete albuminous urine, which usually flows off into the tubules; sometimes however it coagulates in the presence of the shed epithelial cells and gives rise to the stratified fibrinous and nucleated masses (*e*), which we have already described as surrounding the glomerular vessels. The albuminous urine often contains extravasated red and white blood-cells.

The tubular epithelium undergoes the same forms of degeneration as we have described in connexion with parenchymatous nephritis, though the degeneration is usually less intense and less wide-spread: in cases of no very long standing we therefore find the greater number of the tubules still healthy.

By the time that new fibrous tissue has been formed at a particular spot, the corresponding tubules are usually advanced in atrophy. The lumen is narrowed, the secreting epithelium represented by small cubical cells lining the walls or lying loose within the lumen (*h*). Many tubules are empty and collapsed, their epithelium having altogether disappeared (*i*).

The degeneration and atrophy of the tubules is due partly to the disturbances of circulation and nutrition caused by the inflammatory changes, partly to the destruction of the glomeruli (Art. 524).

The contents of the unaffected tubules are the same as in parenchymatous nephritis, though fewer of them contain casts and masses of epithelial detritus. Haemorrhages and pigmentary deposits are likewise less common.

Indurative nephritis and the cirrhotic contracted kidney (Art. 548) correspond partly to the form described by clinical observers as true contracted kidney, partly to so-called secondary contracted kidney. The term "true contracted kidney" has been made to include the arteriosclerotic contracted kidney (Art. 526), whose mode of origin is totally different from that of the cirrhotic contracted kidney. Confusion thus arises, and it may therefore be well in future to avoid the use of the clinical term.

The term "secondary contracted kidney" is applied to cases which begin acutely. This distinction is valueless from the point of view of the morbid anatomist, as such cases differ in no essential respect from those whose onset is gradual or undiscerned.

548. **Terminations of chronic indurative nephritis.** When this affection is not speedily fatal from the extension of the accompanying epithelial degeneration, it may lead in the course of months or years to very extreme induration and obliteration of the secreting structures. The kidney is then always diminished in size, often remarkably so; the capsule is adherent; the surface granulated. The 'granulations' may be coarse or fine, regular or irregular (Fig. 215 *A*).

The tint of the protuberant **granulations** varies greatly.

depending on the amount of blood present in the cortex and on the degree of fatty change in the epithelium. It is usually greyish-

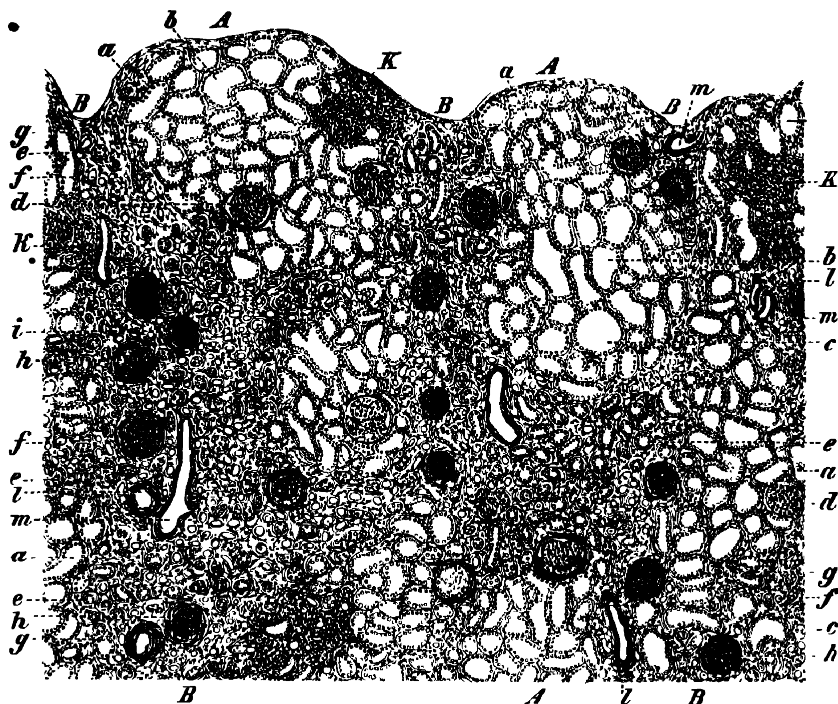


FIG. 215. CIRRHOTIC CONTRACTED (OR 'GRANULAR') KIDNEY.

(*Vertical section through the outer zone of the cortex, stained with alum-carmine and mounted in Canada balsam* × 40)

A persistent renal tissue giving rise to 'granulations'
B cicatricial bands giving rise to depressions and contractions

a normal tubules
b dilated tubules
c cysts
d normal glomeruli
e atrophied and collapsed tubules filled with loose epithelium
f atrophied empty tubules
g hyperplastic fibrous tissue
h atrophied glomeruli with thickened capsules
i the like with normal capsules
k cellular infiltration
l arteriole
m venule

red, sometimes however it is grey or mottled grey and white, or almost entirely white and opaque. The depressions and contractions are usually somewhat redder.

The renal tissue is dense and tough, the cortex thinned, the papillae often truncated or stunted. The tint of the cut surface corresponds with that of the external surface: the medulla is generally somewhat redder, but not infrequently it has much the same tint as the cortex.

The cortical zone is always traversed by fibrous bands with

small islands of less altered or persistent normal tissue lying between them (Fig. 215 *A*).

The fibrous bands start from the intergranular depressions of the surface (*B*) and run towards the bases of the medullary papillae, being interconnected by numerous transverse bands; the islands of normal tissue are therefore more frequently rounded or oval than elongated. The fibrous bands run in general along the course of the veins, though they frequently ramify without any apparent regularity through the labyrinth. The more numerous they are the smaller of course are the islands enclosed in their meshwork. Cases are met with in which the greater part of the labyrinth is thus indurated and obliterated, the only parts retaining their function being parts of the medullary rays and the tissue immediately adjoining. In such cases the surface granulations are naturally very fine and regular; where the cirrhosis is confined to the course of the veins the irregularities of the surface are usually much more marked. The course and mode of extension of the indurative change are in fact very similar to what is observed in cirrhosis of the liver (Art. 496).

The fibrous bands of the cortex always enclose atrophied and collapsed tubules (*e f*) and obliterated glomeruli whose capsules are more or less thickened (*h i*). These bands are thus simply portions of renal tissue of which the secreting structures are rendered functionless and the stroma hyperplastic by chronic inflammation. Here and there a tubule or a glomerulus may persist within the indurated region, while some of the tubules are dilated into cysts by the retention of already secreted urine (*c*).

The islands of persistent secreting tissue may present a normal appearance (*a*). More frequently some of the tubules and glomeruli show signs of compensatory hypertrophy (*b*). Some of the epithelial cells are fatty, though the extent of this change varies much in different cases. Here and there too we find patches of cellular infiltration (*k*), a sign that the inflammatory process is kept up.

Both in the cortex and in the medulla are seen tubules containing hyaline cylinders, or masses of shed epithelium and extravasated leucocytes.

The induration of the intertubular stroma and the loss of the glomeruli involve the obliteration of a considerable portion of the vascular system of the cortex. The vessels passing into the medullary zone (Art. 526) consequently become dilated, though the channels thus opened up never fully compensate for the loss of the cortical channels.

Tuberculous and Syphilitic Nephritis.

549. **Tuberculosis of the kidney** is in most cases due to embolic infection. In rare instances primary tuberculosis of the

bladder, prostate, spermatic duct, or testicle may extend to the kidney by way of the ureter.

Acute miliary tuberculosis and chronic localised tuberculosis are the two forms of the affection.

Miliary tuberculosis of the kidney is merely a part of a general eruption of tubercle in the various organs of the body. Wherever the tuberculous virus lodges, in cortex or medulla, there appears a small semi-translucent greyish speck, which presently grows into a grey nodule. This then becomes whitish, and is often surrounded by a haemorrhagic areola. The whitish tinge is due partly to infiltrated leucocytes, partly to turbid swelling and necrosis of the epithelium set up by the action of the bacilli. When the cellular infiltration becomes great the renal tissue-elements within the infiltrated area perish.

The number of tubercles appearing in the kidney is sometimes very great, sometimes small Occasionally the tubercles are confined to the region supplied by a single twig of the renal artery.

Chronic localised tuberculosis of the kidney begins, like the miliary form, at the spot whither the bacilli have been carried by the blood-stream. This may be either within the parenchyma or in the mucous membrane of the calices or pelvis.

At this spot grey nodules are formed, and presently become caseous. In the course of weeks or months they grow into large irregular nodes by progressive marginal infiltration, while new nodules develope in the tissue around. In the mucous membrane of the pelvis the process extends partly as a diffuse infiltration, partly as a nodular eruption. The nodules and the infiltrated tissue ultimately become necrosed and caseous, and presently disintegrate.

After a time the kidney appears studded with grey nodules and white opaque nodes, the larger of these being softened and excavated The medullary papillae are many of them caseous and broken down, the pelvis appears enlarged by the excavations, and in places is continuous with the tuberculous cavities of the parenchyma. The mucous membrane is infiltrated, thickened, and grey, its surface here and there necrotic and covered with yellow sloughing ulcers; or the deeper layers being uniformly infiltrated and thickened, the entire mucous membrane may be transformed into a cheesy broken-down ulcerous mass.

The tuberculous process frequently extends to the ureter, transforming it into a more or less gristly tube with thickened walls. The inner surface is either white necrotic and ulcerated throughout its entire extent, or it is grey and infiltrated, and studded with scattered patches of necrosis and ulceration.

In the more advanced stages of the disease the kidney appears somewhat enlarged, the capsule adherent, and the surface often rough and irregularly nodulated. Cheesy and granular

detritus occupies the pelvis, which latter by excavation or by retention of urine is abnormally large. In extreme cases the entire kidney is destroyed, nothing remaining but a thick-walled sack containing cheesy or puriform detritus.

As a rule both kidneys are affected, though it is common to find the process much more advanced in one kidney than in the other.

550. **Syphilitic affections of the kidney** exhibiting any special or characteristic features are not common. Renal inflammation referable to the influence of the syphilitic poison is however occasionally met with, and is characterised by the formation of coarse cicatricial bands and of caseating gummata.

In congenital syphilis induration and contraction of the kidney has in somewhat rare instances been observed.

References on renal tuberculosis :—RAYER, *Maladies des reins* Paris 1840; VIRCHOW, *Krankhafte Geschwülste* II; SCHMIDTLEIN, *Deutsche Klinik* 1863; KUSSMAUL, *Würzburger med. Zeitschr.* IV; ROSENSTEIN, *Berl. klin. Woch.* 1865; COLIN, *Gazette hebdom.* X; SOUTHEY, *Brit. Med. Journ.* 1, 1867; MOSLER, *Arch. d. Heilk.* 1863; E. HOFFMANN, *Deutsch. Arch. f. klin. Med.* III; HUBER, *ibid.* IV; KLEBS, *Handb. d. path. Anat.*; EBSTEIN, *Ziemssen's Cyclop.* XV; ARNOLD, *Virch. Arch.* vol. 83; GAULTIER, *La tuberculose rénale primitive* Thèse de Paris 1882; DICKINSON, *Renal and urinary affections* III London 1885; STEINTHAL, *Virch. Arch.* vol. 100; HILTON FAGGE, *Principles and practice of medicine* II London 1886.

On renal syphilis see VIRCHOW, *Krankhafte Geschwülste* II; CORNIL, *Journ. de l'anat.* 1865; MOXON, *Guy's Hosp. Rep.* 1868; LANCEREAUX, *Treatise on syphilis* I (New Syd. Soc.) London 1868; GREENFIELD, *Atlas of Path.* (New Syd. Soc.) London 1879; NEGELL, Thèse de Paris 1884; KLEBS, *loc. cit.*; CORNIL and RANVIER, *Man. d'hist. path.* Paris 1878, *Man. Path. Hist.* II London 1886; the latter found in one case a number of gummata, some of them as large as a pea.

In syphilitic patients we not infrequently find the kidney in a state of amyloid degeneration (MOXON, *loc. cit.*).

In tuberculosis of the urinary organs ROSENSTEIN and BABES (*Cent. f. d. med. Wiss.* 1883) have demonstrated the presence of tubercle-bacilli in the urine.

CHAPTER LXX.

RENAL CYSTS AND HYDRONEPHROSIS.

551. **Renal cysts.** When a urinary tubule is obstructed by a uratic deposit, a tube-cast, a cicatricial band, or other cause, the urine may accumulate behind the obstruction and distend its lumen into a cyst. The like may happen to a glomerular capsule when the mouth of its tubule is blocked.

Kidneys otherwise normal occasionally contain smooth-walled cysts varying in size from that of a pea to that of a walnut and protruding more or less above the surface of the organ. Cysts are however much more frequently met with in diseased kidneys, and especially in the contracted forms due to cirrhosis and arteriosclerosis. THORN states that cysts may also be due to inflammation of the pelvis or calices of the kidney extending by continuity to the stroma of the medullary papillae. In fact it would appear that the compression and obstruction of the tubules resulting from inflammatory change in the tissue about them lead much more frequently to the formation of cysts than internal blocking of the lumen by concretions or deposits. Where a certain amount of constriction has already taken place such internal obstruction may no doubt make the occlusion complete.

The number of these cysts found in a single kidney varies greatly. Cases occur in which they are so numerous as to occupy the whole organ, mere shreds or septa of renal tissue separating the contiguous cavities (cystic degeneration).

The largest cysts met with in kidneys altered by nephritis are about the size of a cherry, the smallest are microscopic. It frequently happens that none are larger than a pea, though in exceptional instances two or more coalesce to form a single cavity.

The larger cysts have thin translucent walls, the inner surface being smooth, and the contents clear or yellowish-brown or slightly blood-stained liquid generally containing urinary salts. The smaller cysts met with in contracted kidneys not infrequently contain a colloid substance. All cysts are lined with epithelium, the cells being usually flattened, rarely columnar.

When the cysts are both large and numerous the kidney may have the look of a large tumour. This condition is sometimes developed before birth, the child being born with kidneys transformed into relatively enormous honeycombed tumours representing an extreme degree of cystic degeneration: this is referred to as **foetal cystic disease.** The tumours may be so large as to interfere with delivery. According to VIRCHOW the condition is sometimes due to inflammatory occlusion and atrophy of the papillae; but THORN thinks it is more frequently brought about by inflammation extending to the substance of the papillae from the calices. Absence of the pelvis or occlusion of the ureters may also have the like effect. Some authorities hold that the condition is due to a primary fault of development.

References:—BRIGHT, *Memoirs on abdominal tumours* (New Syd. Soc.) London 1860; ROKITANSKY, *Lehrb. d. path. Anat.* III 1861; BECKMANN, *Virch. Arch.* vol. 9; FRERICHS, *Die Bright'sche Nierenkrankheit* Brunswick 1851; SIEBOLD, *Monatsschr. f. Geburtskunde* 1854; VIRCHOW, *Gesam. Abhandl.* Frankfort 1856, *Virch. Arch.* vol. 46; BRUCKNER, *ibid.*; HERTZ, *ibid.* vol. 30; SIMON, *Med. chir. Trans.* XXX; KOSTER, *Dublin Quart. Journ.* XLVI; EVE, *Trans. Path. Soc.* XXXI (1860); THORN, *Beitrag z. Genese d. Cystenniere* In. Diss. Bonn 1882; CHOTINSKY, *Ueber Cystennieren* In. Diss. Bonn 1882 (this author affirms that in foetal cystic kidney the occlusion of the tubules is to a great extent due to excessive multiplication of the epithelial cells); CORNIL and BRAULT, *Path. du rein* Paris 1884; DICKINSON, *Renal and urinary affections* III London 1885 (with cases); CORNIL and RANVIER, *Man. Path. Hist.* II London 1886. A number of cases are described in the *Transactions of the Pathological Society.*

552. **Hydronephrosis.** When the escape of the urine from the pelvis of the kidney is prevented or obstructed, it accumulates and distends that cavity, giving rise to what is called hydronephrosis or dropsy of the kidney.

Renal calculi impacted in the ureter, stricture or twisting of the ureter, valvular folds of mucous membrane, or compression by the gravid uterus or by uterine ovarian and vesical tumours, enlarged prostate, urethral stricture, and phimosis—are all possible causes of the condition. In new-born infants the cause of the obstruction is usually some anomaly of the ureter, malposition of the kidney, valvular folds in the ureter, constriction or occlusion of the urethra, enlargement of the prostate or colliculus seminalis, or phimosis.

The pelvis and calices are sometimes enormously distended, forming a sack large enough to fill the greater part of the abdomen and containing 10 to 20 litres of liquid. The part of the ureter above the obstruction is dilated in like manner.

The first result of this accumulation of liquid is the flattening of the papillae and thinning of the cortex of the kidney. The parenchyma persists for a considerable time but at length undergoes atrophy, the tubules being reduced to flattened or cleft-like channels lined with compressed epithelium, and ultimately with the glomeruli becoming functionless and obliterated. In extreme cases the renal tissue is reduced to a thin film or in part disappears

altogether, the sack consisting in great measure merely of fibrous tissue, which in cases of old standing may be of remarkable thickness.

At first the liquid is simply urine; but as the pressure increases less and less urine is excreted, and when the renal tissue atrophies the excretion ceases altogether. The sack however continues to increase in size, owing to the secretion of liquid by the mucous membrane of the pelvis and calices. This liquid contains no urinary matters, but is albuminous; and sometimes it is tinged with blood. Colloid masses and cholesterin are also found in some cases.

Hydronephrosis is usually confined to one side, it is rarely bilateral. When the obstruction affects only a part of the pelvis of the kidney, or when there are two pelves, the hydronephrosis may be partial.

References :—VIRCHOW, *Gesamm. Abhandl.* Frankfort 1856; SAXINGER, *Prager Vierteljahrsshr.* 1867; ACKERMANN, *Deut. Arch. f. klin. Med.* I; HELLER, *ibid.* V; HILDEBRAND, *Sammlung klin. Vorträge* 5; GUSSEROW, *ibid.* 18; SIMON, *ibid.* 88; STADFELDT, *Monatsschr. f. Geburtskunde* 1862; FARRE, *Lancet*, 2, 1861; MORRIS, *Med. chir. Trans.* LIX (1876); EBSTEIN, *Ziemssen's Cyclop.* XV; AUFRECHT, *Die diffuse Nephritis* Berlin 1879 (this author tied the ureter in animals, and observed degeneration of the renal epithelium and afterwards multiplication of the connective-tissue cells); DICKINSON, *loc. cit.*; ROBERTS, *Urinary and renal diseases* London 1885 (with references and cases).

CHAPTER LXXI.

PYELITIS AND PYELONEPHRITIS.

553. When irritant substances are excreted by way of the kidney they frequently set up inflammation in the mucous membrane of the pelvis (**pyelitis**) and ureter. Thus catarrhal, croupous, and diphtheritic inflammation of this membrane may follow or accompany typhoid, scarlatina, small-pox, pyaemia, diphtheria, cholera, nephritis, etc. and the use of drugs like cantharides, copaiba, cubebs, turpentine, etc. When the irritant matter ceases to be excreted the inflammation usually comes to an end also.

These secondary or symptomatic inflammations are not so serious as the more independent and progressive inflammations set up and maintained by the presence in the renal pelvis of parasitic organisms or urinary concretions.

In speaking of parasitic pyelitis we note in passing that tuberculous pyelitis, already described (Art. 549), is due to the invasion of a bacillus. In like manner micro-organisms give rise to the pyelitis which sometimes accompanies suppurative or septic nephritis. Another purulent or suppurative variety is caused by the action of micro-organisms reaching the pelvis from the bladder through the ureter. The latter micro-organisms are usually micrococci, though bacilli and filamentous fungi may also reach the kidney by this channel. They enter the bladder as a rule through the urethra, but cases occur in which they break into it from abscesses in the rectum, uterus, vagina, or pelvic connective tissue.

Bacteria are often introduced into the bladder by means of dirty catheters. In other instances they attack the urethra primarily (as in gonorrhoea), and extend gradually as far as the bladder.

Their lodgment in the bladder is favoured if there be any interference with the evacuation of the urine, such as is caused by stricture or paralysis. When the bladder is incompletely emptied so that some urine remains in it for a considerable time the bacteria which enter it find time to multiply and set up changes

in the urine. As the urine accumulates and the ureters become dilated the bacteria find ready access to the pelvis of the kidney through these channels.

Animal parasites, as well as vegetable, may induce inflammation in the pelvis and ureter. This is especially true of *Bilharzia* or *Distoma haematobium* (Art. 239), whose eggs are deposited and embryos hatched in the urinary tract. *Eustrongylus gigas* (Art. 231) is much less dangerous.

All the forms of concretion described in Arts. 531 and 532 are capable of exciting more or less intense pyelitis. They give rise to continuous mechanical irritation, which in the case of the hard and spiny oxalate-calculi is often very great, and is not slight in the case of the other forms. They produce mischief in another way when they become impacted in the ureter and cause retention of urine as well as local lesions.

554. Pyelitis, set up in the various ways just described, varies much in its symptoms and course. In catarrhal inflammation the mucous membrane is red and swollen, often studded with small extravasations, and secreting a liquid abounding in epithelial cells or pus according to the stage of the disorder. The lymphadenoid tissue existing in variable quantity in the submucosa is often swollen, and appears in the form of grey nodular swellings in the reddened mucous membrane. In chronic cases ulceration and thickening takes place. When the inflammation is diphtheritic patches of the mucous membrane rapidly slough. Bacteria have a very destructive action, as the urine becomes alkaline owing to their multiplication in it, and the products of the decomposition corrode the inflamed tissue Sooner or later the bacteria invade the renal parenchyma. According to KLEBS they advance along the collecting tubes and tubules destroying the epithelium and exciting inflammation.

As a result of this invasion the kidney swells up, often enormously, and looks as if soaked or sodden. At the same time in the cortex and medulla appear a number of small yellow patches surrounded by a zone of hyperaemia, which are simply small patches of suppuration. Purulent pyelitis thus gives rise to **purulent pyelonephritis** (or so-called 'surgical kidney'). The process may issue in induration, but more commonly the suppurating patches grow into large abscesses which burst into the pelvis of the kidney. Not infrequently abscesses form in the tissue immediately surrounding the kidney, and are called **perinephritic abscesses**. If the suppuration within the kidney goes on large pus-secreting cavities communicating with the renal pelvis are produced, and in extreme instances the whole of the kidney is thus destroyed, its place being occupied by a mere pus-containing sack. This condition is referred to as **pyonephrosis**.

Parasitic pyelonephritis may be unilateral or bilateral; in the latter case it is usually more advanced on one side than on the other.

555. **Calculous pyelitis** leads partly to thickening and induration of the affected tissues, partly to ulceration. Not infrequently the inflammation, at least during some part of its course, becomes purulent: occasional haemorrhages are also common.

The inflammation sooner or later extends to the renal parenchyma and leads to swelling and cellular infiltration, terminating in suppuration or in fibroid induration. In either case some portion of the renal tissue is destroyed. The whole of it may perish in extreme cases, leaving nothing but a fibrous sack surrounding the original calculus. Perinephritic abscesses also are frequently produced.

When calculi of some size become wedged in the ureter the outflow of urine may be interrupted. If in consequence of this a considerable accumulation of urine takes place in the pelvis of the kidney we may have hydronephrosis (Art. 552) superimposed on pyelitis. The retained urine often decomposes and thus intensifies the inflammation so that it becomes purulent: in this way pyonephrosis succeeds hydronephrosis.

The impacted stone may be gradually urged forward into the bladder by the pressure of the accumulating urine, giving rise to haemorrhage, erosion, and inflammation on its way.

The ulcers, whether of the ureter or pelvis, may break through externally and thus enable pus to escape into neighbouring parts, such as for instance the intestine or the bladder. More often however the pus escapes into the perinephric (subperitoneal) cellular tissue, and gives rise to wide-spread suppurative or septic inflammation.

Calculous pyelitis is usually unilateral, rarely bilateral.

References:—MICHAELIS, *Wien. med. Presse* XI; EBSTEIN, *Ziemssen's Cyclop.* XV; BRIGHT, *Abdominal tumours* (New Syd. Soc.) London 1860; Discussion, *Internat. med. congress* London 1881 and *Lancet* 1, 1882; J. B. ROBERTS, *Amer. Journ. med. sciences* April 1883 (on perinephritic abscess); ROBERTS, *Urinary and renal diseases* London 1885.

CHAPTER LXXII.

RENAL TUMOURS AND PARASITES.

556. Of the various primary **connective-tissue tumours** of the kidney **sarcoma** presents the greatest interest. Renal sarcoma is usually congenital, and is apparent at birth or becomes noticeable in the first months or years of life. The tumour is sometimes very large (4 to 6 kilogrammes), and consists of soft whitish tissue interspersed with patches of haemorrhagic softening. The mass of the tissue is made up of round, spindle-shaped, and multiform cells. It sometimes contains large transversely-striated spindles (rhabdomyoma, Art. 153). These last have a special interest, for they are evidence that the tumour has arisen in tissue the early stages of whose development have in some way been disturbed (Art. 516).

Cellular **fibromata** are frequently met with in the kidney, and take the form of nodules of the size of a pea or smaller. Large fibrous tumours are very rare, as are also myxomata, lipomata, angiomata, and their combinations. They all of them take the form of nodes seated in the parenchyma or on the capsule of the kidney, or in its pelvis or calices. GRAWITZ has investigated certain small subcapsular tumours, from the size of a pea to that of a cherry, and of a white marrow-like appearance, which have been described as lipomatous: he regards them as simply aberrant and proliferous portions of the suprarenal body. In their structure they are very like the degenerate suprarenals described in Art. 565, consisting of a fibrous stroma with rows and groups of cells containing a variable amount of fat. GRAWITZ has named them "*strumae lipomatodes aberratae renis.*" Telangiectatic tumours (angiomata) in the renal pelvis sometimes give rise to severe haemorrhage.

Adenomata of the kidney appear as well-defined white nodes of the size of a walnut or less, and with a structure like that of ovarian adenomata. WEICHSELBAUM and GREENISH distinguish a papillary and an alveolar variety. The former they say starts in the collecting tubes, and consists of gland-like tubules and acini, studded internally with papillae and lined with cylindrical epithelium. The alveolar form is said to start in the convoluted

tubules and is lined with epithelium like theirs. It is very probable that these growths may develope into carcinomata.

Cancers of the kidney are either soft or hard, and lead to greater or less enlargement of the organ; sometimes the enlargement is very great. In the larger tumours the whole of the renal epithelium may be destroyed by the cancerous growth. The latter may extend into the pelvis. The smaller tumours affect only a portion of the parenchyma and are often fairly well marked off from the sound tissue. The tumours commonly enclose softened and haemorrhagic patches, whence blood and cancerous detritus may reach the urine. Renal carcinoma occurs at all ages, but is relatively frequent in children. In general it is unilateral, though cases are recorded in which a smaller tumour has been found in the second kidney.

Sarcoma and carcinoma are not infrequent as secondary or metastatic growths: they form rounded nodes.

References on myosarcoma:—EBERTH, *Virch. Arch.* vol. 55; COHNHEIM, *ibid.* vol. 65; BRODOWSKI, *ibid.* vol. 67; MARCHAND, *ibid.* vol. 73; BROSIN, *ibid.* vol. 96; KOCHER and LANGHANS, *Deut. Zeitschr. f. Chir.* IX; LANDSBERGER, *Berl. klin. Woch.* 1877; OSLER, *Journ. of Anat. and Physiol.* XIV; HUBER and BOSTROM, *Deut. Arch. f. klin. Med.* XXIII; EVE and WILLIAMS, *Trans. Path. Soc.* XXXI (1882): on primary sarcoma—WINDLE, *Journ. of Anat. and Physiol.* XVIII (with index of cases); SMITH, *Amer. Journ. med. sci.* 1886.

On lipoma and 'struma':—VIRCHOW, *Krankh. Geschwülste* II; KLEBS, *Handb. d. path. Anat.*; STURM, *Arch. d. Heilk.* 1875; SABOURIN, *Arch. de physiol.* IX; GRAWITZ, *Virch. Arch.* vol. 93; EBSTEIN, *Ziemssen's Cyclop.* XV; RICKARDS, *Brit. Med. Journ.* 2, 1883.

On adenoma and carcinoma:—ROBIN, *L'epithelioma du rein* Paris 1855; WALDEYER, *Virch. Arch.* vols. 51, 54; KLEBS, *loc. cit.*; PEREWERSEFF, *Virch. Arch.* vol. 59; WEIGERT, *ibid.* vol. 67; KUHN, *Deut. Arch. f. klin. Med.* XVI; STURM, *Arch. d. Heilk.* XVI; NEUMANN, *Essai sur le cancer du rein*, Paris 1873; ROHRER, *Das primäre Carcinom d. Niere* In. Diss. Zürich 1877, *Virch. Arch.* vol. 67; WEICHSELBAUM and GREENISH, *Wien. med. Jahrb.* 1883; MOORE, *Trans. Path. Soc.* XXXI (1882); Report, *Brit. Med. Journ.* 1, 1884.

557. Of the **animal parasites** inhabiting the kidney *Echinococcus* is the most important. It forms hydatid cysts from the size of a hazel-nut to that of a child's head, with or without daughter-cysts. The cysts may burst into the pelvis of the kidney. When the scolices die the cyst may contract, and its contents become inspissated and cretaceous.

Cysticercus cellulosae and *Pentastoma denticulatum* are very rare. When the blood contains *Filaria* a number of the parasites reach the kidney, lying both without and within the vessels. Their presence in the kidney and in the thoracic duct gives rise to intermittent haematuria and chyluria, the urine in the latter case being milky from the admixture of excessively fine oil-globules (Art. 235).

Eustrongylus gigas and *Bilharzia* or *Distoma haematobium* have already been alluded to (Art. 553). The eggs of the latter when deposited in the mucous membrane of the pelvis or ureter

excite inflammation resulting in ulceration and induration. The more superficial may become encrusted with urinary salts and form sandy grains on the mucous membrane.

When ulceration of the intestine and of the ureter or renal pelvis leads to the formation of abnormal communications between these parts, round-worms occasionally wander into the kidney.

CHAPTER LXXIII.

DISORDERS OF THE BLADDER.

558. **The urinary bladder** is the temporary receptacle of the renal secretion. When the urine is mingled with abnormal exudations from the blood-vessels, or the products of morbid change in the kidney or its pelvis, these are naturally detained for a certain time in the bladder. Of the formed matters thus occurring in its contents the following are the most important.

Red blood-cells or their detritus come either from the kidney or from its pelvis. In the former case they have in general escaped from the glomeruli as a result of disordered circulation (Arts. 523, 527) or of inflammation (Art. 544). They are rarely derived from intertubular haemorrhage. Vascular tumour-growths in the kidney (such as carcinoma or angioma) may also give rise to haemorrhage and haematuria.

When a part of the extravasated blood coagulates in the tubules the urine contains dark and opaque granular cylinders containing blood-cells or their remains and known as **blood-casts.**

Haemorrhage from the pelvis of the kidney is generally due to inflammation and erosion caused by renal concretions.

White blood-cells appear in the urine in inflammatory conditions of the kidney and its pelvis, especially in purulent pyelitis. In chronic suppuration they are for the most part fatty and disintegrated. In tuberculous and other necrotic affections we find bacilli and necrotic detritus in the urine.

Epithelial cells come from the pelvis and from the collecting tubes of the kidney, perhaps too from the loops of Henle and the intercalary tubules. The statement sometimes made—that entire and unaltered epithelial cells from the convoluted tubules escape into the urine—is erroneous. Degenerate cells from the cortex and their detritus are however met with.

The pelvic epithelial cells are polymorphous, resembling exactly those of the bladder itself. The renal cells are cylindrical or cubical: when they are in great numbers and cohere into cylinders we have the so-called **epithelial casts.**

In rare cases **cancer-cells** from a renal tumour are found in the urine.

When albuminous matters escape into the tubules with the urine and there coagulate, we have formed, as already described (Art. 533), the cylindrical masses known as **tube-casts**; and some of these are usually washed out and reach the bladder. They are either entirely colourless and hyaline, or granular, or waxy in appearance and tint. Casts of each of these forms may have adhering to them epithelial cells or their detritus (albuminous and fatty granules), free nuclei, white and red blood-cells, granular deposits of urinary salts, and crystals of calcium urate or oxalate.

When there are **bacteria** in the urine some of them may adhere to the casts: it is however to be noted that the granular masses enveloping some of the casts have of late been erroneously taken for micrococci.

All the urinary deposits and concretions described in Arts. 531 and 532 are ultimately carried into the bladder, unless their size prevents them passing through the ureter. **Scolices** and daughter-cysts occasionally escape from a renal hydatid. And when the ova of *Bilharzia* or *Filaria* are deposited in the mucous membrane of the urinary tract we are apt to find both **ova** and **embryos** in the urine.

559. When the urine has reached the bladder it is liable to be mingled with abnormal products derived either from the diseased bladder-wall or the parts adjoining, or from the exterior.

Blood is one of the most common admixtures, and is met with in cases of intense inflammation, ulceration, or engorgement of the wall of the bladder, and in the vascular lesions accompanying scurvy, haemorrhagic small-pox, scarlatina, etc. Not infrequently traumatic lesions such as are caused by stone or external violence, and tumours such as papilloma, sarcoma, and cancer, are the cause of vesical haemorrhage.

Vesical epithelium is shed into the urine in inflammation (cystitis) and in cases of papillomatous (so-called villous) tumour. In the latter instance villous fragments of the growth are also occasionally found. Masses of **cancer-cells** are frequently found in the urine in cancerous ulceration of the bladder.

In all the forms of cystitis we find **pus-cells** in the urine.

When rupture and perforation of the bladder-wall has taken place matters of very various kinds may reach its interior. A pelvic abscess may yield pus, and ulcerating uterine carcinoma putrid detritus and cancer-cells, a rectal ulcer or fistula faeces, a dermoid cyst its characteristic contents, and so on.

The most common matters entering the bladder from without are **bacteria**, and less frequently **yeast-cells**. If the urine offers them suitable conditions for growth and they are not forthwith removed from the bladder, they proceed to multiply; micrococci and sarcinae do so most readily, bacilli less frequently.

Children and others sometimes pass solid objects (such as pencils, hair-pins, straws, etc.) through the urethra into the

bladder, and pieces of catheters are occasionally broken off and lost in like manner. Now and then shot and bullets which have penetrated the surrounding parts are found loose in the bladder.

560. The causes which give rise to the formation of concretions in the kidney and its pelvis may also give rise to **concretions** within the bladder. As we pointed out in Arts. 531 and 532 acid and alkaline fermentations of the urine are frequently the cause of these deposits, in other cases the cause lies in the nature of the food taken. Not uncommonly however we are unable to detect any sufficient cause.

Very often indeed the basis of a vesical calculus is a concretion which has passed from the pelvis of the kidney into the bladder, or a foreign body introduced from without. On such a basis solid deposits are formed, usually of triple phosphate and acid phosphate of calcium. The foreign bodies in fact set up vesical inflammation and the products of this undergo alkaline decomposition. Deposits of uric acid and urates are much less common.

These deposits take the form of **gravel**, or of **stone**. The stone is usually single, and sometimes reaches a very large size.

A stone is usually spherical or ovoid, and may be smooth, nodular, tuberculated, rough, or even spiny. When more than one are present they are occasionally facetted or polyhedral. Some stones are hard, some soft and friable. They are often stratified or laminar, and made up of a number of different substances.

The presence of a stone generally causes inflammation of the bladder, occasionally ulceration and haemorrhage. As it irritates the bladder it causes it to contract, and sometimes at the same time hinders its evacuation; in this way a stone often leads to hypertrophy of the bladder-wall. At times the stone lies in a diverticulum or sacculation of the bladder, and may there become impacted.

Vesical calculi are classified according to their composition.

(1) Uric-acid and uratic calculi. Pure uric-acid stones are generally small and hard, and of a yellow red or brown tint. Uratic stones (containing urates of ammonium and magnesium) are seldom pure. The superficial layers are usually composed of calcium oxalate and ammonium-magnesium (triple) phosphate.

(2) Phosphatic and calcareous calculi. These consist mainly of calcium phosphate, or of ammonium-magnesium phosphate. Stones consisting entirely of calcium carbonate are very rare. All these stones are white or greyish white. Triple-phosphate stones are soft and friable, the others are hard.

(3) Oxalatic calculi, consisting of calcium oxalate, are hard and spiny; they are brown in colour.

(4) Cystine-calculi are soft brownish-yellow and waxy.

(5) Xanthine-calculi are red, with a smooth surface and earthy fracture.

561. Inflammation of the bladder or **cystitis** is in most cases caused by the presence of irritant matters in the urine (Arts. 558—560), whether due to morbid admixture or to decomposition; it

may also be a result of traumatic injury, or of irritant impurities in the blood.

Catarrhal cystitis is characterised by the occurrence of shed epithelium, pus-cells, mucus, and generally red blood-cells, in the urine. In recent cases the mucous membrane appears but little altered. When the secretion is purulent the membrane is covered with a film of pus, and is sometimes very much swollen. When haemorrhage has occurred the surface is of a uniform grey tint, or mottled with grey black and reddish-brown patches. If the inflammation has extended to the submucous and muscular coats, so that these are infiltrated, the whole wall becomes more or less thickened. In extreme cases the serous or peritoneal surface may be stained with bloody or slaty-grey patches, and at length purulent or putrid exudations may make their appearance in the subperitoneal tissue (**pericystitis**) and on the peritoneum itself. This of course happens only in very intense suppurative or septic inflammations, such as are set up by septic (bacterial) decomposition of the contents of the bladder.

Certain irritants, such as cantharidin, lead from the outset of the affection to superficial sloughing of the epithelium, which becomes detached in the form of necrotic flakes and shreds. Such infective disorders as measles, scarlatina, typhoid, septicaemia, etc. are occasionally accompanied by superficial diphtheritic desquamations in the form of isolated yellowish patches; in other instances the exudation is croupous.

When the urine becomes ammoniacal and putrid the epithelial layers, the connective tissue of the mucosa and submucosa, and even the muscular coat may in parts become necrosed and ulcerated, and at length gangrenous and putrid. In this way ulceration, gangrene, and abscess of the bladder-wall are developed, and ultimately perforation may occur at one or more points, with the result of secondary suppuration and necrosis in the neighbouring tissues.

In the severer forms of cystitis the mucous surface is frequently rough and sandy with incrusted salts, chiefly triple-phosphate.

As we have already pointed out (Art. 553) inflammation of the bladder may extend to the ureters and the kidney, especially when there is retention of urine ('surgical kidney').

In **chronic cystitis** fibrous hyperplasia of the coats of the bladder, with true hypertrophy of its muscular coat (Art. 563), is a common occurrence.

Tuberculosis of the bladder begins with the formation of grey nodules surrounded by a zone of hyperaemia; these enlarge and turn yellow, and sooner or later break down into ulcers. The ulcers have a cheesy infiltrated floor and their borders are hyperaemic. They increase in size by progressive marginal disintegration and by coalescence, and in this way are formed large sinuous ulcerations, involving a considerable part of the mucosa

and submucosa. Vesical tuberculosis is usually accompanied by tuberculosis of the pelvis of the kidney (Art. 550) or, in the male, of the genital apparatus: it is indeed probable that the process starts in some part of the latter system.

The mucous membrane of the urinary tract, and especially that of the bladder, frequently contains a number of small aggregations of lymphadenoid tissue, and in catarrhal cystitis these become perceptibly swollen. They then look very much like tubercles, especially when they are surrounded by a hyperaemic zone.

Long-continued engorgement of the vesical blood-vessels leads to varicose dilatations of the veins, chiefly those near the neck of the bladder. They are sometimes referred to as **vesical haemorrhoids**, and now and then obstruct the evacuation of the bladder or give rise to haemorrhage.

Amyloid degeneration of the vesical mucous membrane is not rare, but as a rule it is not apparent without the aid of the microscope. In very rare instances the amyloid deposits may lead to induration of the mucosa and submucosa.

References :—VIRCHOW, *Krankhafte Geschwülste* II; EBSTEIN, *Ziemssen's Cyclop.* XV; KLEBS, *Handb. d. path. Anat.* I; MAAS, *Krankh. d. Blase* (*König's Handb. d. Chirurgie*); CHAVASSE, *Étude sur la tuberculose des organes urinaires* Paris 1872; VOISIN, *Tuberculose des organes génito-urinaires*, *Bulletin de la soc. anat. de Paris* XLIX (1874); KIRMISSON, *Cystite*, *ibid.* L (1875); DURAND, *Cystite chronique*, *ibid.* LII (1877); STEINTHAL, *Virch. Arch.* vol. 100; DU CASAL, *Cystite chronique*, *Gaz. hebd. de méd.* 1877; W. ROBERTS, *Brit. Med. Journ.* 2, 1881; HARRISON, *Internat. encyclop. of surgery* VI London 1886.

562. The commonest of the **tumours** of the bladder is the so-called '**villous cancer**' or vascular papillomatous **fibroma.** It consists of a number of long and slender villi or papillary growths, springing from a comparatively narrow base: each villus consists of a delicate stroma containing wide and thin-walled vessels and covered with stratified epithelium. The growth does not extend into the deeper layers of the mucous membrane, and sometimes attains the size of a small apple. It is single or multiple, and is usually situated towards the base of the bladder not far from the neck, so as sometimes to obstruct the channel during micturition. The vessels and the stroma being alike delicate and fragile, the tumour is very apt to bleed and may thus prove very dangerous to the patient. From time to time fragments of the villi are detached and passed with the urine. The growth is not malignant and should not be described as a 'cancer.'

Primary **carcinoma** of the bladder is a very rare growth; it occurs both in men and women and takes the form of a nodular or fungous or papillary tumour, at times extending over a considerable part of the bladder, and penetrating the submucous and even the muscular coat. The cancerous infiltration may thence extend into neighbouring parts.

Secondary carcinoma is more frequently met with, the in-

fection reaching the bladder from the uterus, vagina, rectum, or prostate.

Other neoplasms of the bladder are very rare indeed.

* LANGHANS recently described a case of vesical angioma (*Virch. Arch.* vol. 86); GUSSENBAUER (*Arch. f. klin. Chir.* XVIII) and VOLKMANN (*ibid.* XIX) cases of myoma, SCHATZ (*Arch. f. Gynäk.* x) of fibromyxoma, POSNER (*Berl. klin. Woch.* 1883) of primary carcinoma. See also STEIN, *Tumors of the bladder* Philadelphia 1881, *New York Med. Rec.* 1885 (with references to the recorded cases).

563. **Dilatation of the bladder** takes place when its evacuation is interfered with through occlusion or stricture of the urethra or paralysis of the muscular wall of the bladder itself. When the evacuation is rendered difficult, or when frequent contraction of the bladder is induced by the stimulus of a stone, the muscular coat may **hypertrophy**. The wall becomes thickened and the overgrown muscle-bundles stand out from the inner surface in a reticulum of bands or fasciculi.

Diverticuli are produced either by the simultaneous sacculation of all the coats, or by the protrusion of the mucous and submucous coats through the meshes of the fasciculated muscular coat. These diverticula are seldom larger than a walnut. They frequently are the seat of concretions, and sometimes are first caused by the pressure of a calculus.

Displacements of the bladder are rare, though occasionally a part of the viscus prolapses into a hernial sac. The base of the bladder may also fall down into the vagina (vaginal cystocele), or the posterior wall may prolapse through the dilated female urethra and appear at the external orifice.

Rupture of the bladder results from traumatic injury, excessive distention, or morbid change in the wall. Rupture into the peritoneum usually leads to fatal peritonitis. After perforations into the pelvic cellular tissue urinary infiltration takes place, leading to gangrene or suppuration in the tissue invaded. Ulceration or local necrosis sometimes leads to the opening of abnormal communications between the bladder and the vagina, uterus, rectum, or external cutaneous surface. These are called **urinary fistulae**, and are kept open by the constant escape of urine through them.

CHAPTER LXXIV.

MORBID CHANGES IN THE URETHRA.

564. The **inflammations of the urethra** correspond generally with those of other mucous membranes. Croupous and diphtheritic inflammations are rare, but catarrh is very frequently met with. The most important form of catarrh is **gonorrhoea**, which is set up by a specific micrococcus (NEISSER, HAAB, MARTIN). The micrococcus is conveyed to the urethra in the secretion from another mucous membrane affected with gonorrhoea, and multiplying sets up an inflammation characterised by its purulent catarrhal exudation, which is yellowish or greenish-yellow and sometimes slightly blood-stained. The inflammation may extend from the urethra to other parts of the urinary tract and to the neighbouring genital organs, and ultimately affect (by metastasis) remote regions like the joints, as in gonorrhoeal rheumatism.

The inflammation may also extend in the urethra from the mucous to the submucous strata, and thence to the periurethral connective tissue and the lymphatics.

It usually ends in recovery, though in places it may lead to ulceration and abscess, to fibrous hyperplasia, corrugation and thickening of the mucous membrane, or cicatricial contraction. These are most common in chronic cases (**gleet**, *goutte militaire*).

Other forms of urethral inflammation are the soft chancre or **chancroid** (Art 391), the **hard chancre** or initial sclerosis of syphilis (Art. 391), and lupous and tuberculous disease. Ulceration is frequent behind the site of strictures, and it readily extends to the urethra from prostatic ulcers. When the ulceration goes deeply fistulous tracts may be formed, leading to urinary infiltration of the surrounding tissue and ultimately to abscesses and permanent urinary fistulae. In the male these fistulae have sometimes a very irregular almost labyrinthine course, and open either on the exterior or into the rectum.

A not uncommon after-effect of chronic inflammation is the development of polypous and papillary growths, such as the '**cauliflower excrescences**' (*condylomata acuminata*) or 'caruncles' which appear round the orifice of the urethra in women.

Varices, resembling rectal haemorrhoids, are sometimes formed at the site last-named in consequence of long-continued inflammatory hyperaemia.

The most common **tumours** affecting the female urethra are sarcoma, myxoma, fibroma, and carcinoma. Fibroma gives rise to nodes and nodules, or to vascular papillomatous growths. In males cancer of the prostate or of the glans penis frequently attacks the urethra. Small **cysts** of retention are occasionally formed in the mucous glands of the female urethra.

Stricture of the urethra is proximately due to inflammatory swelling of the mucous membrane, to nodular or diffuse unilateral or annular fibrous hyperplasia, to cicatrices, to valvular folds of membrane, or to polypous growths. Gonorrhoeal inflammation and traumatic injury are the most common exciting causes. Inflammatory strictures are oftenest seated in the membranous and in the contiguous spongy part of the canal. In old men the **enlarged prostate** frequently obstructs and even occludes the urethra. In infants and young children the colliculus seminalis is sometimes so excessively developed as to interfere with micturition.

Traumatic rupture of the urethra arises in various ways; a very common cause is careless catheterisation by which 'false passages' are produced. They are usually situate at the deeper end of the canal, and either end blindly or lead into the urethra again or into the bladder.

Such ruptures give rise to urinary infiltration and abscess, or to fistulae surrounded by dense fibrous tissue and partially lined with epithelium.

References on the micrococcus of gonorrhoea (*gonococcus*):—NEISSER, *Cent. f. med. Wiss.* 28, 1879, *Deut. med. Woch.* 20, 1882; BOKAI, *Pest. med.-chir. Presse* 1880; CHEYNE, *Brit. Med. Journ.* 2, 1880; HAAB, *Corresp. f. Schweizer Aerzte* 1881, *Der Mikrokokkus d. Blenorrh. neonatorum* (*Horner's Festschrift* 1881); KRAUSE, *Cent. f. prakt. Augenheilk.* 1882; MARTIN, *Recherches sur les inflam. métast. suppur. à la suite de la gonorrhée* Geneva 1882; BOCKHART, *Vierteljahrsschr. f. Derm. u. Syph.* 1883; STERNBERG, *Philad. Med. News.* 1883—84; WELANDER, *Gaz. méd. de Paris* 1884; LOMER, *Deut. med. Woch.* 1886.

CHAPTER LXXV.

MORBID CHANGES IN THE SUPRARENALS.

565. **Malformations** of the suprarenals are not common: though sometimes there are more than two or there are small accessory bodies of like structure; or on the other hand they are imperfectly developed or absent altogether. The latter is usually the case only when other malformations of the viscera are present.

Fatty degeneration is a normal phenomenon in the adult; it is apparent chiefly in the cells of the cortical layer, which thereby acquire a pale-yellow tint.

Amyloid change of the blood-vessels is not infrequent as an accompaniment of amyloid disease in other organs; it may give rise to induration.

Pigmentation is a very common occurrence in old age, affecting chiefly the deeper layers of the cortex. The cells are either of a uniform yellow tint or beset with pigment-granules.

Haemorrhage is somewhat uncommon, though cases occur in which the extravasation is so great as to cause the organ to swell enormously. It is then due either to mechanical injury, or to vascular disorder. VIRCHOW describes an acute haemorrhagic form of inflammation of the suprarenals.

Inflammation of the suprarenals is not frequently observed, though it does occur in various forms. Thus in acquired and in hereditary syphilis cellular infiltrations and gummatous inflammations are described. And in other cases inflammation ending in suppuration or in cicatricial induration has been noted.

The commonest as well as the most important variety of inflammation is that which terminates in **caseous and fibroid degeneration** of the gland: in most cases it is apparently of a tuberculous nature. The suprarenals are more or less enlarged, the capsule thickened and adherent to the neighbouring structures. The surface is either smooth or nodular and misshapen: on section the parenchyma appears in great part replaced by dense fibrous tissue enclosing caseous foci of various sizes. These latter may contract or be absorbed, whereupon the organ becomes distorted and shrunken; in other instances they become calcified. The disease is usually bilateral. Sometimes abscesses are formed.

The **tumour** oftenest observed in the suprarenals is that described by VIRCHOW as *struma lipomatosa suprarenalis:* it is a nodular growth consisting essentially of fatty glandular tissue. Carcinoma and sarcoma also occur, the latter often reaching a very large size.

Suprarenal **cysts** have also been described by various observers. They are formed either by the softening of haemorrhagic patches, or by the dilatation of the cortical acini (KLEBS). These true cysts must not be confounded with the cavities very frequently observed in the glands, which are due to post-mortem softening of the inner layers of the cortex.

The *Echinococcus* is the only **animal parasite** met with in the suprarenals.

Disease of the suprarenals, especially the caseous fibroid degeneration, is often accompanied by **bronzing of the skin** (*cutis aenea*) and buccal mucous membrane, and by a profound and fatal cachexia. The pigmentation is sometimes uniform and diffuse, sometimes in patches and streaks. The bronzing and the cachexia are supposed to depend on the suprarenal lesion; the affection being referred to as *melasma suprarenale* or **Addison's disease.** In many cases changes in the abdominal sympathetic nerves and ganglia have been observed. No satisfactory explanation of the relation of the several phenomena has yet been given.

References :—ADDISON, *On the constitutional and local effects of disease of the suprarenal capsules* London 1855, reprint (New Syd. Soc.) 1868; HECKER, *Monatsschr. f. Geburtskunde* XXXIII (1869); VIRCHOW, *Krankh. Geschwülste* II; KLEBS, *Path. Anat.* I; AVERBECK, *Die Addison'sche Krankheit* Erlangen 1869; WOLF, *Berl. klin. Woch.* 1869; GREENHOW, *Croonian lectures* London 1875, *Trans. Path. Soc.* (many papers), *Trans. inter. med. congress* II London 1881; BURGER, *Die Nebenniere u. d. Morbus Addisonii* Berlin 1883; CHIARI, *Wien. med. Presse* XXI (1880); FLEISCHER and PENZOLDT, *Deut. Arch. f. klin. Med.* XXVI (1880); HUBER, *ibid* IV; GOODHART, *Atlas of Pathology* (New Syd. Soc.) London 1879, *Trans. Path. Soc.* XXXIII 1882; DA COSTA and LONGSTRETH, *Amer. Journ. med. sciences* July 1880; SAUNDBY, *Brit. Med. Journ.* 1, 1883; BARLOW and COUPLAND, *Trans. Path. Soc.* XXXVI 1885.

MARCHAND (*Virch. Arch.* vol. 92) has recently pointed out that accessory suprarenals are not uncommonly to be found in the broad ligament near the ovary. On suprarenal tissue in and about the kidney see Art. 556.

SECTION X.

THE RESPIRATORY ORGANS.

CHAPTER LXXVI.

INTRODUCTORY.

566. The **organs of respiration** fall naturally into two groups distinguished by differences both of structure and of function. The one includes the **lungs**, in which chemical interchanges between the blood and the air are effected; the other is the system of **air-passages** by which the lungs are placed in communication with the exterior.

The air-passages include the nose, larynx, trachea, and bronchi. From the point of view of morbid anatomy these are regarded simply as cavities lined with mucous membrane, and the morbid changes they undergo are conditioned chiefly by changes in this membrane. Certain parts of this system of passages perform functions other than that of air-conduction—for instance, the nasal mucous membrane contains the peripheral olfactory apparatus, and the larynx the mechanism of voice—but the fact affects but little the pathological relations of these parts. These functions involve the presence of certain structures in the epithelial wall of the air-passages, and these are sometimes secondarily (sometimes also primarily) affected when the latter is morbidly altered.

The general considerations set forth in Section VI (Arts. 414—431) are accordingly in the main directly applicable to the case of the mucous membranes of the nose, larynx, trachea, and bronchi.

The pathological relations of the lungs themselves (*i.e.* of the respiratory tissues) are however of an essentially different kind. The peculiar structure of this part of the respiratory apparatus gives a special and peculiar character to its morbid anatomy and to the clinical course of the diseases affecting it.

The disorders of the respiratory organs are for the most part due to deleterious influences affecting their tissues through the medium of the respired air. The affections which are traceable to disturbances of the circulation or to alterations in the blood are however by no means insignificant. Affections due to extension of morbid processes from contiguous parts are comparatively infrequent.

CHAPTER LXXVII.

THE NASAL CAVITIES.

567. Congenital **malformations of the nose** which are at all extreme are met with only in combination with other malformations of the face. Thus in *Cyclopia* (Art. 7) the nose may be wanting or represented by a snout-like projection beneath the single orbit. Minor anomalies are—the absence of some of the nasal muscles, defects of the septum, of the ethmoid, or of the nasal bones, constriction or closure of the posterior nares, obliquity or distortion of the septum, and clefts of the alae nasi or of the floor of the nostrils. The latter occur in connexion with cleft-palate and cleft-face (Art. 8).

Haemorrhage from the nasal mucous membrane (**epistaxis**) is very common, and may be due either to diapedesis or to rupture of blood-vessels. In many persons epistaxis is habitual: in others it occurs most frequently in connexion with the haemorrhagic diathesis, and in various infective diseases, menstrual disorders, venous engorgement, inflammatory conditions, etc.

Inflammation of the nasal mucous membrane (**rhinitis**) is one of the commonest affections. It usually takes the form of a mucous or purulent catarrh (Art. 420); the croupous, diphtheritic, phlegmonous, and ulcerative varieties are much less common.

Acute nasal catarrh is spoken of as **coryza**, and may result from a great variety of causes, such as cold, inhalation of irritant matters, micro-organisms, etc.

Chronic nasal catarrh occurs chiefly in persons who are scrofulous, phthisical, or syphilitic: it is comparatively rare in persons otherwise healthy. Sometimes it results in thickening, sometimes in thinning or even atrophy, of the mucous membrane. In the latter case the nasal cavity appears abnormally large, and its walls secrete a yellowish or greenish pus which undergoes putrid decomposition and gives rise to a foetid odour (**ozaena** simplex) and to the formation of dirty greenish crusts and scales. FRÄNKEL points out that in this form of atrophy the Bowman's glands disappear, and it is very probable that the alteration in the nasal secretion thereby occasioned makes it possible for septic

organisms to lodge in the mucous membrane. In many chronic cases the bone underlying the mucous membrane likewise undergoes atrophic change. FRANKEL thus speaks of simple ozaena as *rhinitis chronica atrophica foetida.*

Croupous and diphtheritic inflammation of the nose is usually secondary to the like affection in the throat (Arts. 423—426). Phlegmonous inflammation (Art. 427) is usually due to extension from neighbouring parts, though it is sometimes confined to the nose.

Ulcerative inflammation is in most cases due to syphilis (Art. 429) or to glanders (Art. 430). Lupous (Art. 392), tuberculous (Art. 428), and leprous (Art. 430) infiltration and ulceration are also met with, but they are rare. The syphilitic and tuberculous affections of the nose frequently begin in the periosteum of the nasal bones and give rise to more or less extensive destruction of the osseous tissue.

All the inflammatory affections of the nose may extend by continuity to the cavities and sinuses connected with it and there take on a more or less independent character, the cavities becoming filled with mucous or purulent secretion. From the frontal or ethmoidal sinuses the inflammation may extend into the interior of the cranium and so give rise to meningitis.

References on ozaena :—HUPPERT, *Begriff und Ursachen der Ozaena* In. Diss. Strasburg 1879 ; B. FRANKEL, *Ziemssen's Cyclop.* IV ; MICHEL, *Krankh. d. Nasenhohle und d. Nasenrachenraumes* Berlin 1876 ; E. FRANKEL, *Virch. Arch.* vols. 79, 87, 90 ; HARTMANN, *Deutsche med. Woch.* 13, 1878 ; GOTTSTEIN, *Breslauer arztl. Zeitschr.* 17, 1879 ; KRAUSE, *Virch. Arch.* vol. 85, *Trans. internat. med. congress* III London 1881 ; B. ROBINSON, *Nasal Catarrh* New York 1880 ; FRANKS, *Dublin Journ. med. science* 1881, 1882 ; MARTIN, *De l'ozène vrai* Thèse de Paris 1881 ; MORELL MACKENZIE, *Diseases of the throat and nose* II London 1884 (with full references) ; LOWENBERG, *Deut. med. Woch.* 1885.

References on nasal lupus :—HEBRA and KAPOSI, *Diseases of the skin* IV (New. Syd. Soc.) London 1875 ; MOINEL, *Le lupus scrofuleux des fosses nasales* Paris 1877.

References on nasal tuberculosis :—WEICHSELBAUM, *Allg. Wiener med. Zeitung* 27 and 28, 1881 ; TORNWALDT, *Deut. Arch. f. Ohrenheilk.* X, *Deut. Arch. f. klin. Med.* XXVII ; BRESGEN, *Der chron. Nasen- und Rachencatarrh* Vienna 1883 ; ZUCKERKANDL, *Norm. u. path. Anat. d. Nasenhohle u. ihrer pneum. Anhange* Vienna 1882 ; DEMME, *Berl. klin. Woch.* 1883 (states that tuberculosis may attack the nose primarily) ; VOLKMANN, *Samml. klin. Vortrage* 168, 169.

References on phlegmonous inflammation of the nasal cavities :—WEICHSELBAUM, *Wiener med. Jahrb.* 1881 ; KOHTS, *Gerhardt's Handb. d. Kinderkr.* III ; B. FRÄNKEL, *Ziemssen's Cyclop.* IV.

568. The nasal mucous membrane is not infrequently the seat of hyperplastic growths and of tumours, due partly to chronic inflammation, partly to unrecognised causes. They take the form of polypous excrescences and are usually referred to as **nasal polypi.**

Soft or mucous polypi resemble the mucous membrane in

structure, but are somewhat more cellular. Sometimes the included mucous glands are dilated into cysts (cystic polypi) especially in the antrum of Highmore, or these glands are enlarged and multiplied as in glandular or adenomatous polypi, or traversed by numerous thin-walled blood-vessels (telangiectatic polypi or 'erectile' tumours).

Other polypi consist of oedematous connective tissue and mucoid tissue, and are therefore classed as fibromata and myxomata. They are more translucent than the former, and are usually of a yellowish tint, the mucous polypi being grey or greyish-red.

Sarcoma, dense fibroma, osteofibroma, chondroma, osteoma, carcinoma, and mixed tumours of the connective-tissue group, have been met with in the nose. Many of these start not in the mucous membrane but in the periosteum of the nasal bones. The connective-tissue tumours, especially those originating in the periosteum, may reach a considerable size, distending the cavity in which they grow, sometimes protruding from the anterior and posterior nares, and much distorting the face.

Carcinoma of the nose is most frequently met with about the anterior nares and is therefore to be classed with the cutaneous forms of cancer. The cancers which originate in the mucous membrane take the form of irregularly nodulated growths, which sooner or later ulcerate.

Rhinoliths are calcareous concretions, formed as a rule round some foreign body which has become impacted in the nasal cavity. In rare instances they are due to the inspissation of nasal secretions.

Maggots or larvae are sometimes hatched in the nose from eggs deposited by various species of *Diptera*. They may give rise to extensive inflammation and sloughing. (See MORELL MACKENZIE, *Diseases of the throat and nose* II London 1884.) Of **vegetable parasites** bacteria and the *Saccharomyces albicans* are the commonest. The former are usually innocuous, though in certain cases, as in ozaena, they set up decomposition in the nasal secretions. In tuberculosis and in glanders the characteristic bacilli are found.

References on nasal tumours:—VIRCHOW, *Krankhafte Geschwülste* I, III; BILLROTH, *Ueber den Bau der Schleimpolypen* 1855; MATHIEU, *Les polypes muqueux* Thèse de Paris 1875; THUDICHUM, *Polypus in the nose* London 1877; DURHAM, *Holmes's Syst. of surgery* II London 1883; KOHTS, *Gerhardt's Handb. d. Kinderkrankh.* III; HOPMANN, *Virch. Arch.* vol. 93, *Wien. med. Presse* 1883; ZUCKERKANDL, *Norm. u. path. Anat. d. Nasenhohle* Vienna 1882; LEFFERTS, *Internat. encyclop. of surgery* V London 1885; MORELL MACKENZIE, *Diseases of the throat and nose* II London 1884: the last two give many references to published cases.

CHAPTER LXXVIII.

THE LARYNX.

569. **Malformations.** Entire absence of the larynx is very rare as a congenital anomaly; it is met with only in amorphous and acephalous acardiac monsters in whom the lungs are undeveloped (Art. 13). Congenital defects, as of the epiglottis or of part or the whole of one of the laryngeal cartilages, are much commoner. Asymmetry and abnormal largeness or smallness of the larynx are also met with: abnormal smallness frequently accompanies aplasia of the testicle or early castration. Sometimes the laryngeal cartilages are abnormal in number, and the epiglottis more or less deeply cleft. The ventricles of the larynx or sinuses of Morgagni are not uncommonly of abnormally great capacity, and occasionally we find extra-laryngeal pouches communicating with them. This anomaly is of special interest, inasmuch as it is a normal feature in the *Quadrumana*.

Of acquired deformities **laryngeal stenosis** is the most noteworthy. It may be due to pressure from without, but more commonly to disease of the larynx; for example, to inflammation by which the mucous membrane becomes swollen and covered with a solid exudation or undergoes cicatricial contraction, or to the growth of intra-laryngeal tumours. Functional stenosis may be brought about by paralysis of the muscles which open the glottis or spasm of the muscles which close it. Foreign bodies impacted in the glottis may have the same effect.

The morbid anatomy of the larynx has been very thoroughly discussed by EPPINGER (*Klebs's Handb. d. path. Anat.* part 7 vol. II Berlin 1880).

Numerous references to the pathology of laryngeal affections will be found in the following text-books:—RAUCHFUSS, *Gerhardt's Handb. d. Kinderkrankh.* III Tübingen 1878; VON ZIEMSSEN, *Ziemssen's Cyclop.* IV, VII; TÜRCK, *Klinik d. Krankheiten d. Kehlkopfes* Vienna 1866; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884; P. BRUNS, *Die Laryngotomie* Berlin 1878; MORELL MACKENZIE, *Diseases of the throat and nose* I London 1880.

570. **Affections of the laryngeal mucous membrane.** Laryngeal catarrh is very common, and is characterised by redness

and swelling of the mucous membrane together with a mucous, purulent, or serous exudation. Serous exudation is observed chiefly in catarrhs due to persistent passive hyperaemia. The inflammation may extend over the entire organ or be limited to certain parts such as the vocal cords or the epiglottis. It may be induced by very various causes.

In **chronic catarrh** the blood-vessels are sometimes permanently dilated. The epithelium desquamates freely and often accumulates round the vocal cords in whitish films and patches, which form a nidus for bacteria. The mucosa and submucosa are infiltrated with leucocytes. The fibrous strata frequently become hypertrophied and thickened. When the papillary structures of the glottis also are hypertrophied they assume the form of papillomatous or warty growths. The mucous glands of the posterior surface of the epiglottis, the false cords, and the sinuses of Morgagni may become enlarged and dilated, and give the surface a granulated appearance (**granular laryngitis**). Loss of epithelium and rupture of the dilated and distended glands give rise to small erosions and ulcerations. Loss of continuous patches of epithelium is most frequently observed about the vocal cords and their posterior attachments, and is often due to the action of bacteria or of the thrush-fungus (Fig. 76, Art. 198).

In chronic catarrh of long standing and in consequence of ulceration the glandular structures become obliterated and the mucous membrane thinned and atrophied. Slight but often-repeated irritation is sometimes followed by hypertrophy of the squamous epithelium, which gives the affected spots a white or pearly appearance. The vocal cords are the parts most commonly affected, and they are sometimes the seat of polypous excrescences at the same time (Art. 575).

Croupous inflammation of the laryngeal mucous membrane is sometimes primary, sometimes secondary to inflammation in neighbouring parts. It is most common in connexion with diphtheria, small-pox, typhoid, and cholera, though it may also result from the inhalation of hot or irritant gases and vapours or from the introduction of foreign bodies. The interior of the larynx is covered with white or yellowish more or less coherent false membranes or only with white curdy flakes; these are sometimes readily removed, sometimes slightly adherent. The latter is the case when the epithelium of the affected part is stratified and squamous (Arts. 423—426).

The false membranes consist in part of fibrinous filaments and meshes enclosing pus-corpuscles, in part of lustrous homogeneous flakes. When they are stripped off the underlying mucous membrane is red and raw-looking.

Diphtheritic inflammation with sloughing and gangrene of the mucous membrane occurs most frequently in connexion with diphtheria and typhoid, though it is rare even in these diseases.

References :—EPPINGER, and RAUCHFUSS, *loc. cit.*: VON ZIEMSSEN and STEINER, *Ziemssen's Cyclop.* IV; RHEINER, *Virch. Arch.* vol. 5; E. WAGNER, *Arch. d. Heilk.* VII (1866); STEUDENER, *Virch. Arch.* vol. 54; WEIGERT, *ibid.* vol. 70; SCHOTTELIUS, *Gesellsch. d. Naturwissenschaften zu Marburg* XII; Report, *Brit. Med. Journ.* 2, 1878; MORELL MACKENZIE, *op. cit.*, *Diphtheria* London 1878; Report, *Lancet* 1, 1879, and *Med. chir. Trans.* LXII (1879); MONTI, *Croup u. Diphtherie* Vienna 1884; VIRCHOW, *Berl. klin. Woch.* 1885; ORTH, *Path. Anat.* II Berlin 1885.

It will be seen that we make no pathological distinction corresponding to that implied in the clinical terms *croup* and *diphtheria*. The specific infective disease diphtheria, when it is accompanied by croupous or superficial diphtheritic inflammation of the larynx and trachea, is the same as the affection clinically described as 'membranous croup,' a term which the pathologist may well dispense with (Arts. 204, 443, 444).

571. **Oedema of the glottis** is a more or less intense swelling of the laryngeal mucous membrane, due to infiltration of the mucosa and especially of the submucosa. The swelling is usually greatest on the posterior surface of the epiglottis, the aryteno-epiglottic folds, and the false vocal cords, the submucosa of these parts being exceptionally loose in texture. The oedema may be so great as to occlude the superior orifice of the larynx.

Oedema of the glottis may be acute or chronic. The former is due to inflammatory exudation, and occurs chiefly as a concomitant of catarrhal, croupous, or diphtheritic inflammation, and around syphilitic and tuberculous ulcers and submucous or perichondritic abscesses. It may also accompany suppurative inflammations of the pharynx, thyroid gland, and cervical connective tissue. It is often unilateral or confined to one of the parts above mentioned, according to the exciting cause.

Chronic oedema is usually the result of venous engorgement from cardiac disease, pulmonary emphysema, compression of the cervical veins, etc., and of non-inflammatory affections of the blood or vessels: it is generally symmetrical and limited to the posterior surface of the epiglottis and the aryteno-epiglottic folds, though in a less degree it may affect the vocal cords. Chronic inflammatory conditions of the larynx (as in laryngeal ulcer or perichondritis) may of course give rise to inflammatory oedema of a somewhat chronic kind.

Phlegmonous inflammation of the larynx (*phlegmon laryngis*) is a sero-purulent and sero-fibrinous infiltration of the submucosa and mucosa, whose seat is generally the same as that of acute oedema: it is not common.

Suppuration of the tissue succeeds the infiltration, and abscesses are formed which on rupturing give rise to ulcers. When the inflammation extends to the cartilages purulent perichondritis is set up (Art. 576). These abscesses may also burrow in among the cervical muscles, or break into the pharynx or oesophagus. When the pus is evacuated the abscess-cavity may close up and become cicatrised.

Phlegmonous laryngitis sometimes follows upon croupous,

diphtheritic, and gangrenous inflammations, and upon tuberculous and syphilitic ulcerations. In other cases inflammations of the perichondrium or of the pharynx or tonsils, or mechanical injury, are the inducing cause. The forms of laryngitis which sometimes accompany typhoid, scarlatina, and pyaemia occasionally issue in suppuration.

572. **Specific forms of laryngitis.** We thus observe that the various forms of laryngeal inflammation result from very various causes, some of them being specific. Certain specific forms are distinguished by no definite characters from the non-specific; but there are others, notably those accompanying some of the infective diseases, which exhibit anatomical lesions more or less definite. The diseases in question are typhoid, small-pox, tuberculosis, syphilis, glanders, and lupus.

Typhoid is frequently accompanied by a catarrhal laryngitis marked by epithelial desquamation, ecchymoses, and superficial erosions, and by linear cracks in the mucous membrane, especially about the edges of the epiglottis. Sometimes the posterior surface of the epiglottis, the anterior wall of the larynx, and the vocal cords are covered with a branny slightly adherent 'fur' consisting of dead epithelium, leucocytes, micrococci, and microbacteria. Sometimes too on the false and true vocal cords there are ulcers, the floor and edges of which are beset with bacteria.

EPPINGER regards these bacteria as the specific organisms of typhoid, and thinks they are the cause of the epithelial necrosis and ulceration: he therefore describes the affection as *necrosis mycotica typhosa*. The bacteria are very probably the cause of the local destruction of tissue, but it seems highly doubtful that they are the virus of typhoid.

Different forms of bacteria are found in the affected spots, and the like changes are produced in affections other than typhoid (Fig. 76, Art. 198). It is therefore probable that different organisms are carried from the mouth, settle in the catarrhal mucous membrane, and there set up destructive changes.

Less frequently than the above we find in the larynx of typhoid patients diffuse swellings or miliary nodules, due to intense cellular infiltration of the mucous membrane. EPPINGER regards these as specific typhoid lesions analogous to those of the intestine. They occur chiefly at the base of the epiglottis, the false vocal cords, the inner aspect of the arytenoid cartilages, and the anterior attachment of the vocal cords: by disintegration of the infiltrated tissue they give rise to erosions with raised borders resembling typhoid ulcers. These ulcers, whether bacterial or infiltrated, may extend both in breadth and in depth, affecting ultimately the perichondrium of the several cartilages. In consequence of this we not infrequently observe large losses of substance with necrosis of the affected cartilages. The latter occurs chiefly when as sometimes happens the perichondritis becomes suppurative or gangrenous.

The laryngitis of **small-pox** is characterised by the appearance on the reddened mucous membrane of minute whitish spots or small lentil-like nodules. According to EPPINGER the former are due to cloudy swelling and granular degeneration, the latter to cellular infiltration, of the epithelium. Sometimes a branny coating of dead epithelium and pus-corpuscles, or coherent croupous membranes, cover the affected parts. In all of these micrococci can be found (EPPINGER), and are probably the exciting cause of the local affection. Epithelial haemorrhages make their appearance in cases of haemorrhagic small-pox; and in the later stages small abscesses may form in the connective tissue. Larger perichondritic abscesses and necrosis of cartilage are however comparatively rare.

Scarlatina gives rise to catarrhal laryngitis, seldom to the croupous or diphtheritic forms: and the like is true of measles and typhus.

References:—LOUIS, *La fièvre typhoïde* Paris 1841; TROUSSEAU, *Clinical Medicine* II (New Syd. Soc.) London 1869; EPPINGER, *loc. cit.*; TOBOLD, *Laryngoscopie* Berlin 1874; HEINZE, *Die Kehlkopfsschwindsucht* Leipzig 1879; JOFFROY, *Arch. de physiol.* 1880; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884; MURCHISON, *Continued fevers* London 1884; KUHLE, *Sammlung klin. Vorträge* 6; GRAVES, *Clinical Lectures* (New Syd. Soc) London 1884—85.

Erysipelas may extend from the face and mouth to the pharynx and larynx, and give rise to oedematous and phlegmonous inflammation (CORNIL, *Arch. générales* XIX 1862; MORELL MACKENZIE, *op. cit.*; MASSEI, *D. primäre Erysipel d. Kehlkopfes* Berlin 1886).

573. **Tuberculous laryngitis** is a very common complication of tuberculous disease of the lung (laryngeal phthisis), though it also occurs independently. In the former case the specific infection is doubtless conveyed by the sputum; in other cases the virus reaches the mucous membrane by way of the blood or lymph.

The process begins with the development of small subepithelial cellular infiltrations, projecting somewhat above the surface as greyish nodules. These either caseate rapidly and breaking through the epithelium give rise to minute ulcerations, or extend beneath the surface in the form of a diffuse granulomatous infiltration containing typical tubercles and giving rise to irregular protuberances of the mucous membrane. Sooner or later caseation and disintegration set in, and ulcers are formed whose floor and margins are infiltrated or even caseous. Secondary changes presently appear in the form of disseminated patches of inflammatory infiltration in the mucosa, submucosa, or perichondrium, sometimes in the mucous glands or more rarely between the laryngeal muscles. These patches may also coalesce into larger masses of granulomatous tissue containing tubercles simple or caseous. This is most apt to happen about the perichondrium of the various cartilages.

Large tuberculous granulations are very commonly met with on the under surface and edges of the epiglottis, or on the posterior and anterior walls of the larynx. In the vocal cords on the other hand disintegration usually sets in before granulations of any size

are developed. There is however no invariable rule in the matter: the extent of the tuberculous infiltration and of the ensuing ulceration varies greatly in different cases. Sometimes there are only a few punctiform ulcers on the vocal cords or posterior laryngeal wall, in other cases large areas of mucous membrane are destroyed and the cartilages also are involved in the necrotic process.

Tuberculous ulceration is always accompanied by a certain amount of catarrh: oedema of the glottis or phlegmonous inflammation are also occasional complications.

References:—EPPINGER, *loc. cit.*; HEINZE, *Die Kehlkopfsschwindsucht* Leipzig 1879; VON ZIEMSSEN, *Ziemssen's Cyclop.* VII, and supplement 1881; MORELL MACKENZIE, *op. cit.*, and *Brit. Med. Journ.* 1, 1879; BIEFEL, *D. Arch. f. klin. Med.* XXX 1882; SOLIS COHEN, *Amer. Journ. med sci.* 1883. HEINZE believes that the tuberculous metastasis from the lungs to the larynx takes place through the blood and not by means of the sputa. This is however very unlikely: the sputa from a tuberculous lung contain bacilli and are infective, they may therefore very well convey the specific infection to the larynx.

RINDFLEISCH affirms that the tuberculous ulceration starts from the mouths of the mucous glands. This may sometimes be the case, but it is not the rule.

574. The first symptoms of **syphilitic laryngitis** may be those of a simple catarrh, though the accompanying infiltration of the mucous membrane is often extreme. The affection usually follows upon syphilitic disease of the pharynx, and is doubtless an extension of the latter.

At a later stage deep erosions appear, whose floor and edges are densely infiltrated. Prominent greyish-white or red patches are formed on the surface of the mucous membrane (*condylomata lata, plaques muqueuses*), which also ulcerate as a rule; sometimes however the infiltration is re-absorbed and they disappear.

These erosions or ulcers vary much in extent and in depth. The floor of the larger ulcers is covered with a grey film: when this is removed the characteristic whitish exudation appears beneath. The epiglottis, the vocal cords, and the posterior wall of the larynx are the most frequent seats of ulceration. In rare cases the whole of the interior of the larynx is denuded and the cartilages laid bare.

A second form of syphilitic ulceration is due to the breaking down of gummata; these are usually seated in the submucosa and are not due to direct infection from the pharynx. They are most common in the epiglottis and vocal cords, and may be so large and numerous as to obstruct or occlude the larynx.

Small gummatous nodes may be re-absorbed, but the large ones usually soften in the centre and break through into the larynx, giving rise to flask-shaped ulcers with infiltrated edges. The ulceration may extend into the laryngeal wall and cause perichondritis and necrosis of cartilage: in this case the inflammation takes on a purulent or suppurative character.

The syphilitic process may come to a stand-still at any stage, the ulcers healing up by cicatrisation. If the healing is delayed considerable portions of the larynx, such as the epiglottis or vocal cords, may be entirely destroyed. The greater the loss of substance the larger is the cicatrix, and the distortion of the parts due to its contraction may be extreme: sometimes indeed the cavity of the larynx is constricted to a narrow and tortuous passage. The vocal cords occasionally become adherent, or the glottis is encroached on by protuberant bands of scar-tissue.

The islands of mucous membrane lying between the cicatrices are often thrust or bulged out in the process, and if they become inflamed and infiltrated or hyperplastic they take the form of outgrowths and papillomatous or polypous excrescences (*condylomata acuminata*) which still further obstruct the air-passage.

Lupus of the larynx may accompany lupus of the pharynx and of the nose. It gives rise to nodular infiltrations and ulcers with a thickened edge and granulating floor, which yield a scanty secretion. Cicatricial contractions are formed, causing distortion and obstruction as in the case of syphilis.

Leprosy likewise gives rise to nodes and nodules in the larynx which coalesce into larger tumour-like growths. The subsequent ulceration, cicatrisation, and cicatricial contraction may cause very great distortion of the parts.

In **glanders** disseminated inflammation is set up, which is characterised by the formation of subepithelial cellular nodules. These break down and ulcerate, and in this way extensive destruction of the mucous membrane takes place.

References:—EPPINGER, *loc. cit.*; VON ZIEMSSEN, *loc. cit.*; VIRCHOW, *Krankhafte Geschwülste* II; GERHARDT and ROTH, *Virch. Arch.* vols. 20, 21; SOMMERBRODT, *Wiener med. Presse* 20, 1870, *Berl. klin. Woch.* 1878, *London Med. Record* 1878; TURCK, *Atlas d. Kehlkopfkrankheiten* Vienna 1866; SCHECH, *Deut. Arch. f. klin. Med.* XX, *D. Zeitschr. f. pract. Med.* 1877; WHISTLER, *Med. Times and Gaz.* 2, 1878; HAUFF, *Die Rotzkrankheiten beim Menschen* Stuttgart 1855 (glanders); BOLLINGER, *Ziemssen's Cyclop.* III, and supplement 1881; J. MACKENZIE, *Amer Journ. med. sci.* 1880 (congenital syphilis); LEWIN, *Berl. klin. Woch.* 41, 1881; CHIARI and RIEHL, *Viertelj. f. Derm. u. Syph.* 1882 (lupus); THIN, *Brit. Med. Journ.* 2, 1884 (leprosy).

575. **Mucous polypi** of the larynx are not common; but now and then we meet with polypous thickenings of the false vocal cords, whose structure is exactly similar to that of the mucous membrane.

Papillary or villous growths are much more common and are described as **papillomata** or papillary fibromata. Some of them are of inflammatory origin, others appear to be non-inflammatory or simply hyperplastic. They generally grow from the true vocal cords and sometimes extend over a considerable area. They take the form either of compact nodulated tumours, or warty growths, or 'cauliflower' excrescences. These latter are not infrequently multiple and are especially common in young persons (P. BRUNS).

Fibromatous nodules are also most frequently met with on the vocal cords. They have broad or narrow bases, and are smooth or warty, usually of the size of a lentil or small pea but sometimes as large as a hazel-nut. Some are pale, others vascular, some hard, others soft.

Lipoma and myxoma are very rare. Sarcoma is somewhat more frequent; it generally resembles a nodular fibroma, but is rather softer. Chondromata have been several times described: they start from the cartilages and form small knotty growths.

Primary **carcinoma** is most apt to arise about the vocal cords and the laryngeal sinuses. It takes the form of nodular or papillary growths or of diffuse infiltrations, which break down and leave sinuous ulcers with an irregular floor. The ulceration is usually accompanied by purulent inflammation. The destruction of tissue is sometimes very extensive, going far beyond the limits of the larynx.

Secondary cancerous growths are more common, extending into the larynx by continuity from the oesophagus, pharynx, or thyroid gland. True carcinomatous metastasis is somewhat rarer.

A few cases of adenoma have been noted; the growth takes the form of an irregular nodose tumour.

Cysts due to retention of secretion in the mucous glands are usually met with in the laryngeal sinuses and about the epiglottis; but they are not very common.

Of the **parasites** of the larynx other than the specific and other bacteria already mentioned we need only refer to the *Saccharomyces* or *Oïdium albicans* (Arts. 224, 436) or thrush-fungus, and the *Trichina spiralis* (Art. 232). The fungus gives rise to the characteristic white films; the *Trichina* lodges in the laryngeal muscles. Now and then round-worms (*Ascaris lumbricoides*, Art. 228) find their way into the glottis and give rise to attacks of dyspnoea.

References on laryngeal tumours:—EPPINGER, *loc. cit.*; VON ZIEMSSEN, *loc. cit.* (for recent bibliography by LEFFERTS see supplement London 1881) FAUVEL, *Traité d. maladies d. larynx* Paris 1877; VON BRUNS, *Neue Beobacht. üb. Kehlkopfpolypen* Tubingen 1873, 1878; OERTEL, *Deut. Arch. f. klin. Med.* XV; MORELL MACKENZIE, *Growths in the larynx* London 1876, and *op. cit.*; BUROW, *Berl. klin. Woch.* 13, 1877, *Laryngoskopisch. Atlas* Stuttgart 1877; BESCHORNER, *Berl. klin. Woch.* 42, 1877; P. BRUNS, *Die Laryngotomie zur Entfernung intralaryngealer Neubildungen* Berlin 1877 (the latter and also VON ZIEMSSEN describe laryngeal tumours consisting of thyroid-gland tissue); ZIEGLER, *Virch. Arch.* vol. 65 (tumours consisting solely of amyloid substance); BUTLIN, *Malignant disease of the larynx* London 1883; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884; ASCH, *New York Med. Journ.* 1884 (chondroma, with references); CERVELATO, *Lo Sperimentale* 1881 (cysts, with cases); SCHROETTER, *Monatschr. fur Ohrenheilkunde* 1884 (lipoma).

According to P. BRUNS out of 1100 tumours of the larynx 602 were papillomata, 346 fibromata, 73 mucous polypi, and 27 cysts. 76 per cent. of the tumours were situated on the true vocal cords or at their anterior attachment.

On round-worms in the larynx see KUCHENMEISTER and ZÜRN (*Die*

Parasiten d. Menschen Leipzig 1882), FÜRST (*Wien. med. Woch.* 1879), MOSLER (*Zeitschr. f. klin. Med.* VI 1883).

576. The **laryngeal cartilages** are apt in old age to undergo certain degenerative changes which we may perhaps describe as physiological. These are fibrillation, partial solution, and transformation into spongy osseous tissue. The process corresponds in details to the metaplasia or pathological ossification of the other cartilages of the body. The spongy bone thus produced may afterwards be partially replaced by fatty myeloid tissue or marrow.

This softening and ossification also occurs as a morbid change at an earlier age, especially in cases of chronic laryngitis. The transformation into bone begins in the deeper parts of the cartilages and thence extends towards the surface.

Bile-pigment is deposited in the cartilages in cases of jaundice, and urates in gout.

The most important affection is however the inflammation of the perichondrium, referred to as **laryngeal perichondritis**. It is usually a secondary affection, occurring in connexion with suppurative and ulcerative disease and with carcinoma, and is especially frequent in pyaemia, small-pox, typhus, and severe typhoid. Sometimes it originates in the decubital necroses met with in aged and debilitated bedridden patients at the posterior aspect of the cricoid cartilage (Art. 450), and due to the persistent pressure of the larynx on the vertebral column. Perichondritis may also be set up by mechanical violence.

The inflammation is usually purulent, but tuberculous, caseous, and indurative varieties are met with. It is nearly always localised to some part of the cartilaginous framework of the larynx, most commonly to parts of the cricoid and arytenoids. The accumulated exudation lying on the surface of the cartilage gives rise to more or less marked swelling of the parts, and presently portions of the cartilage become necrosed. When the perichondritic abscess bursts either outwards or inwards the dead sequestrum may be exfoliated and extruded. Abscesses bursting inwards usually give rise to inflammation of the bronchi and lungs, those which burst outwards to perilaryngeal suppuration.

After the abscess is evacuated and the dead cartilage removed the wound may heal by granulation and cicatrisation. When the loss of substance is large much contraction and distortion ensue. Smaller defects are filled up with fibrous tissue, actual regeneration of the lost cartilage taking place only to a very slight extent. So too in fracture of the cartilages from external violence repair takes place by means of new formations of fibrous tissue not of cartilage.

Now and then cartilaginous excrescences, or **ecchondroses**, make their appearance, and in cases where the cartilages have already become ossified exostoses have been described. They are usually found about the articulations, but are nearly always very

small, not exceeding the size of a pea. A few instances of still larger growths are however on record.

References:—SCHOTTELIUS, *Die Kehlkopfknorpel* Wiesbaden 1879; TURCK, *loc. cit.*; EPPINGER, *loc. cit.*; MORELL MACKENZIE, *Trans. Path. Soc.* XXII (1871); GERHARDT, *Deut. Arch. f. klin. Med.* XI; BRIEGER, *Zeitschr. f. klin. Med.* III; JAHN, *Virch. Arch.* vol. 72; LITTEN, *ibid.* vol. 66; VON ZIEMSSEN, *Ziemssen's Cyclop.* VII.

CHAPTER LXXIX.

THE TRACHEA.

577. **Malformations** of the trachea are not common. In acephalous monsters it is sometimes absent, the larynx and the lungs being sometimes present, sometimes not. Occasionally we meet with cases of abnormally short trachea, and of atresia or narrowness of this or one of the main bronchi. As a result of imperfect separation of the air-passage from the alimentary canal we may have a persistent communication between the trachea and the oesophagus, usually a little above the bifurcation of the former. When the two ends of the communicating passage become closed, it is transformed into a mucous cyst lined with ciliated epithelium.

Not infrequently some of the rings of the trachea are wanting; and in other cases they are abnormally coherent, or subdivided, or multiplied. The bifurcation may take place at an abnormally high level, or the first branch of the right bronchus may arise directly from the trachea.

Lastly we may have persistent remnants of the branchial clefts opening into the trachea, giving rise to so-called cervical fistulae (Art. 8). These have recently acquired considerable interest inasmuch as VOLKMANN has shown that they may be the starting-point of carcinomatous growths.

Acquired **dilatations** of the trachea are not very common; though we occasionally meet with cylindrical, fusiform, or sacculate dilatations due probably to expiratory pressure, when expiration is obstructed and the tracheal wall more yielding than usual. Sacculate dilatations are commonly situated on the posterior aspect of the tube.

Stenosis of the trachea is in general caused by compression from without; more rarely it is due to structural changes, or to growths and tumours of the tube itself. Goitre and other tumours of the neck, peritracheal abscesses, and aneurysms of the aorta may be the cause of compression: cicatrices and other hyperplastic formations may give rise to obstruction from within.

Compression may be unilateral or bilateral. When it is very chronic it may induce atrophy of the cartilages (ROSE) or lead

to their transformation into fibrous tissue: it is however worthy of remark that sometimes no degenerative change is observed even when the compression has been extreme.

Perforation of the trachea, apart from mechanical injury, is most frequently due to cancerous and sarcomatous ulceration of the oesophagus or thyroid gland, and to aortic aneurysm, peritracheal abscess, or suppurating lymphatic glands: it is much less commonly caused by ulceration within the trachea. In cases of aneurysm the thinned-out wall of the sack pushes in the interannular spaces; and this is observed also in the case of carcinomatous and sarcomatous and of goitrous tumours.

Foreign bodies which become impacted in the trachea in general speedily set up inflammation and ulceration.

Wounds of the trachea are repaired by cicatricial tissue: regeneration of cartilage takes place only to a very slight extent.

References:—EPPINGER, *loc. cit.*; CRUVEILHIER, *Traité de l'anat. path.* II; GRUBER, *Virch. Arch.* vol. 47; VIRCHOW, *Krankhafte Geschwülste* III; DEMME and FURST, *Gerhardt's Handb. d. Kinderkrankh.* III; WEIL, *Deut. Arch. f. klin. Med.* XIV (1873); ROSE, *Langenbeck's Arch. f. klin. Chir.* XXII; RIEGEL, *Ziemssen's Cyclop.* IV; ELDRIDGE, *Amer. Journ. med. sci.* 1879 (sacculations); SCHOTTELIUS, *Die Kehlkopfknorpel* Wiesbaden 1879 (repair of wounds); BRISTOWE, *St Thomas's Hosp. Reports* III; VOLKMANN, *Cent. f. d. med. Wiss.* 1882.

578. The **inflammations of the trachea** have few special features, and are frequently associated with inflammatory affections of the larynx. Catarrh is sometimes due to non-specific irritation, sometimes it is a complication of infective diseases such as measles, small-pox, whooping-cough, influenza, syphilis, etc. Laryngitis or bronchitis (Art. 579) usually accompanies this latter form. Croupous inflammation is most common in diphtheria, and is characterised by the formation of a white fibrinous false membrane. Diphtheritic denudation or ulceration of the mucous membrane is not common.

Miliary **tuberculosis** of the tracheal mucous membrane is rare. Chronic tuberculosis is more frequent: it gives rise to extensive subepithelial infiltrations, which afterwards break down and form ulcers of various sizes. Sometimes it extends to the deeper structures, laying bare and partially destroying (by perichondritis) the cartilaginous rings. In rare cases the greater part of the mucous membrane is destroyed by ulceration.

Syphilitic disease produces lesions resembling those of the larynx; indeed it frequently extends from the latter downwards; it may however appear in the trachea independently. In this case it is usually deep-seated, and is often associated with syphilis of the bronchi. The specific inflammation may give rise to extensive destruction of tissue, extending to the cartilaginous structures: the cicatrices which result often cause by their contraction very remarkable distortion and stenosis of the tube, which may be beset in every direction with coarse fibrous bands. The edges of the syphilitic

ulcers are sometimes the seat of papillary excrescences partly covered with stratified squamous epithelium.

After tracheotomy **granulations** sometimes spring from the internal wound, and seriously obstruct the air-passage.

Primary **tumours** of the trachea are rare. Fibroma, sarcoma, chondroma, osteoma, adenoma, and carcinoma, have been observed. Secondary growths due to extension from the oesophagus or thyroid gland are more common.

Cysts arise from retention of secretion in the mucous glands. They are usually situated on the posterior wall and may be as large as a walnut: as a rule they protrude into the space between the trachea and the oesophagus. EPPINGER asserts that the mucous glands may become distended with air forced into them through their ducts.

References on tracheal syphilis:—GERHARDT, *Deut. Arch. f. klin. Med.* II, III (1867); BEGER, *ibid.* XXIII; MORELL MACKENZIE, *Trans. Path. Soc.* XXII (1871), and *op. cit.*; RAUCHFUSS, *Gerhardt's Handb. f. Kinderkrankh.* III; TÜRCK, *loc. cit.*; KOCH, *Langenbeck's Arch. f. klin. Chir.* XX; BERGER, *Schmidt's Jahrbucher* 1881 (with a summary of the literature).

References on tracheal tumours:—ROKITANSKY, *Path. Anat.* IV (Syd. Soc.) London 1852; STORCK, *Pitha u. Billroth's Handb. d. Chirurg.* III; SCHRÖTTER, *Wien. med. Jahrb.* 1868, 1870; STEUDENER, *Virch. Arch.* vol. 42; SIMON, *ibid.* vol. 57; LANGHANS, *ibid.* vol. 53; VIERLING, *Deut. Arch. f. klin. Med.* XXI; KOPP, *ibid.* XXXII.

CHAPTER LXXX.

THE BRONCHI.

579. The morbid changes affecting the larger bronchi in general correspond closely to those of the larynx and trachea. There are however certain peculiarities connected with them, arising partly from their anatomical structure and partly from their relation to the lungs.

Hyperaemia and **anaemia** of the bronchi have no very distinctive characters. We may however note that both in engorgement and in congestion the bronchial mucous membrane may appear of a very deep red or purple tint.

Haemorrhage from the mucous membrane is not uncommon: it takes the form of small ecchymoses or of larger effusions which mingle with the bronchial secretion. These are due to disturbance of the circulation or to morbid changes in the vessels or tissues. In haemophilia, whether congenital or acquired (purpura), and more rarely in catarrhal inflammations, the haemorrhage may be much more considerable and may partially fill the bronchi, while extensive suffusions appear in the mucous membrane. When the menses are suppressed it is said that haemorrhage from the bronchi sometimes occurs. The blood effused into the bronchi may be aspirated into the lung and simulate pulmonary haemorrhage.

The commonest of all bronchial affections is **bronchitis**. In catarrhal bronchitis the secretion from the inflamed mucous membrane is mucous, serous, purulent, or mixed. The mucus so abundantly secreted in the acute stage comes partly from the lining epithelium, partly from the mucous glands of the bronchial wall. Little plugs of mucus (which sometimes simulate tubercles) may be seen protruding from the orifices of these glands. The cellular elements contained in the bronchial secretion are nearly all pus-corpuscles. Epithelial cells are never abundant, inasmuch as they do not readily desquamate and when they do they usually become mucoid and dissolve (Arts. 420, 421).

When the secretion is very abundant, serous, and containing few cellular elements, the affection has been called serous **broncho-rrhoea**; when the secretion is more puriform **bronchoblenno-**

rrhoea. Sometimes the secretion decomposes and becomes foul-smelling under the influence of septic *micro-organisms, and we have* then foetid or **putrid bronchitis**. In all forms of bronchitis the mucous membrane is more or less densely infiltrated with cells: this is most marked however in the purulent or putrid forms, in which the infiltration extends even to the peribronchial tissue. The causes of bronchitis are very numerous, some of them acting through the inspired air, some through the blood. Foetid bronchitis is most frequently associated with dilatation of the bronchi (bronchiectasis) or with gangrene of the lung, but it also occurs independently of these.

Croupous bronchitis is usually an accompaniment of croupous tracheitis, and is almost always due to the specific virus of diphtheria: it may however be set up in other ways, as for example by the aspiration of liquid from the mouth In croupous pneumonia there is always a certain amount of croupous inflammation of the smaller bronchi. The mucous membrane is covered over with whitish films whose thickness (except in croupous pneumonia) is not great in any but the larger bronchi · in the smaller tubes mere specks and shreds of fibrin are formed, and as we pass to the finest bronchioles these gradually disappear and are replaced by catarrhal secretion.

There is also a chronic fibrinous or **plastic bronchitis** in which from time to time firm coherent membranes form in the bronchi, and are coughed up as continuous tree-like casts of the ramifying tubes

Diphtheritic and **gangrenous inflammation** of the bronchial mucous membrane are rare They are generally set up by gangrenous or necrotic detritus coughed up from the lung, or by powerfully irritant matters which have been inspired The inflammation thus induced is sometimes haemorrhagic, and patches of the mucous membrane and of the deeper structures of the bronchial wall become gangrenous and are thus destroyed

Tuberculous inflammation of the bronchi is a common accompaniment of tuberculous disease of the lung. It is usually



FIG. 216. TUBERCULOSIS OF THE BRONCHIAL MUCOUS MEMBRANE (× 25)

a columnar epithelium
b fibrous tissue of the mucosa infiltrated with leucocytes
c tubercle
d margin of a small tuberculous ulcer

most marked in the smaller tubes communicating with the diseased region: in other cases it is diffused over the greater part of the

bronchial system. Here as elsewhere the affection begins with the formation of grey cellular nodules (Fig. 216), which project somewhat above the surface. These caseate and break down, and in this way small ulcers (*d*) are formed, whose floor and edges are usually covered with a whitish necrotic film and surrounded by a zone of hyperaemia.

The disintegration of the infiltrated margins of the ulcer steadily advances, and the ulcer grows and coalesces with others, so that at length large irregularly-shaped erosions are formed which sometimes extend to the cartilages of the bronchial wall. In the smaller tubes we frequently find the entire wall invaded and ulcerated away.

Syphilitic inflammation of the bronchi is not often seen: it presents the same appearances as in the trachea and larynx. Extensive loss of substance is occasionally caused by it; as recovery takes place coarse puckered cicatrices are formed, and these may give rise to notable contraction and distortion of the bronchi.

The bronchi are provided with a stratified epithelium, consisting of flat basal cells, transitional cells, and columnar cells. Some of the latter are ciliated cylindrical cells, others are mucus-producing goblet-cells, which in catarrhal conditions undergo mucoid degeneration. The capillaries of the mucous membrane empty themselves chiefly into the pulmonary veins, not into the bronchial veins: to this fact is due the readiness with which the membrane becomes engorged when the pulmonary circulation is overloaded (KUTTNER, *Virch. Arch.* vol. 73).

The tissue of the bronchial wall contains lymphoid elements, and in the larger bronchi these are in places aggregated into groups lying between the muscular coat and the cartilages: in this way lymphadenoid nodules are formed which look not unlike tubercles.

References :—FRANKENHAUSER, *Bau der Tracheobronchialschleimhaut* St Petersburg 1879; J. ARNOLD, *Virch. Arch.* vol. 80; KOLLIKER, *Zur Kenntniss d. Baues d. Lunge* Würzburg 1881; ROSSBACH, *Ueber d. Schleimbildung in d. Luftwegen* (Festschrift) Würzburg 1882; RIEGEL, *Ziemssen's Cyclop.* IV.; WEIL, *Gerhardt's Handb. d. Kinderkrankh.* III; SOKOLOFF, *Virch. Arch.* vol. 68; HAMILTON, *Path. of bronchitis* London 1883.

CURSCHMANN recently described (*Deut. Arch. f. klin. Med.* XXXII) under the name of 'exudative bronchiolitis' a peculiar form of bronchitis in which tough hyaline or greyish or yellowish coagula are formed, 0·5—1 mm. thick and 1—2 cm. long, and consisting of spiral or convoluted filaments and strings enclosing a variable number of cells. They are due to an exudative process affecting the bronchioles, which is neither simple catarrh nor croupous inflammation. According to VIERORDT (*Berl. klin. Woch.* 1883) similar coagula are occasionally met with in other inflammatory affections, as in croupous pneumonia.

In various forms of bronchitis, but especially in the croupous and exudative varieties, the secretion contains slender acicular colourless octahedra of various sizes, which are known as Leyden's crystals: they are probably identical with Charcot's crystals (compare Art. 260), and seem to consist of some substance containing mucin (SALKOWSKI). Their occurrence is accidental, and it is possible that they are formed in or from lymphoid cells: they may form in the sputum after it has left the body (UNGAR).

References :—PEACOCK, *Trans. Path. Soc.* V 1854; CHARCOT, *Gaz. hebdom.* 47, 1860; LEYDEN and SALKOWSKI, *Virch. Arch.* vol. 54; ZENKER, *Deut. Arch. f. klin. Med.* XVIII, XXXII; CURSCHMANN, *loc. cit.*; UNGAR, *Cent. f.*

klin. Med. 1880, *Congress f. innere Med.* Wiesbaden 1882; PRAMBERGER, *Ueber fibrinöse Bronchitis* Graz 1881.

580. **Stenosis** and **occlusion** of the bronchi are generally the result of inflammation. When the bronchial wall is infiltrated and the mucous membrane covered with exudations and secretions, the air-passage is always to a certain extent obstructed, and some of the smaller bronchi are frequently blocked up entirely. As a rule this obstruction passes away, the morbid accumulations (mucus, pus, croupous exudations, etc.) being removed by absorption and expectoration, while the swelling of the bronchial wall gradually goes down.

Sometimes however the secretions are only imperfectly removed, and the obstruction persists for a considerable time. This is most frequently the case in the apices of the lungs, where the respiratory movements are less marked than in other parts. Secretions which are rich in cells or which become inspissated and viscid are apt to cause chronic obstruction. Chronic thickening of the bronchial wall, whether from cellular infiltration or fibrous hyperplasia, has much the same effect.

Persistent obstruction of the bronchi may result from simple acute or chronic inflammation, but it is far more commonly due to tuberculous inflammation. This is owing to the fact that in tuberculosis

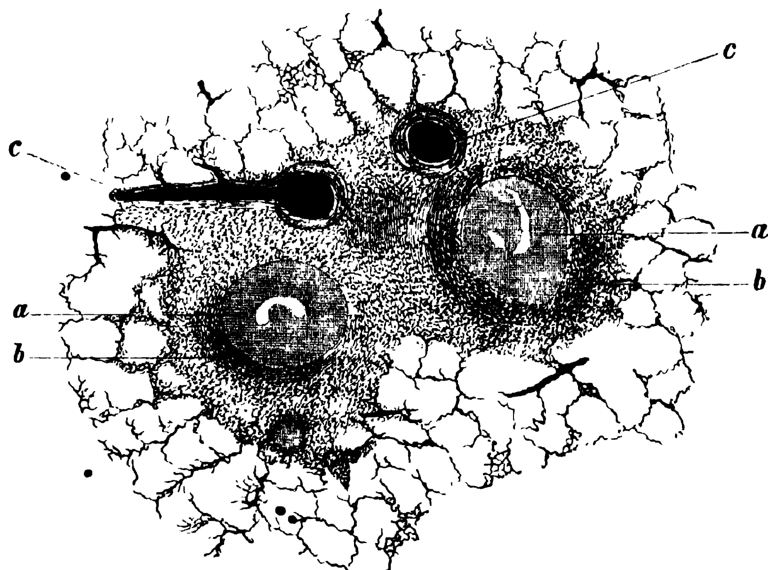


FIG. 217. TWO OCCLUDED BRONCHIOLES FROM A TUBERCULOUS LUNG.

(*Preparation injected with Prussian blue, and stained with ammonia-carmine:* × 25)

a caseous contents of the bronchioles
b bronchial wall and peribronchial tissue thickened and infiltrated with cells
c arterioles

we have not only thickening and infiltration of the bronchial wall but also a secretion which contains many cells and little liquid.

In chronic pulmonary tuberculosis the bronchi are always affected, and hence there are always a certain number of obstructed bronchioles in the diseased region (Fig. 217): in many cases indeed most of the smaller tubes are occluded, and this fact contributes essentially to produce the characteristic appearance of the consolidated lung.

The contents of an occluded bronchus always become caseous (*a*), so that on section it looks like a round encapsulated caseous node. Only when a considerable length of the tube is filled with caseous detritus and when the section cuts it more or less longitudinally does it present the appearance of a cylindrical or elongated deposit. The boundary between the caseous contents and the bronchial wall is sometimes sharp and distinct, sometimes ill-defined. The former appearance is more characteristic of obstruction from catarrhal bronchitis, the latter of tuberculosis. The bronchus and the tissue around it are generally thickened in the neighbourhood of the caseous deposit. The thickening after catarrh is oftenest simply fibroid, after tuberculous inflammation (Fig. 217 *b*) it is more cellular and in part necrotic and caseous.

The caseous contents of the tubes may after a time become calcified.

Foreign bodies also may by impaction cause obstruction of the bronchial tubes. They give rise, according to their chemical and physical character, to indurative, purulent, or it may be putrid, inflammation.

The cicatricial formations which follow upon destructive inflammation may by their contraction cause marked constriction and obstruction of the bronchi: this is well seen in syphilitic disease of the larger tubes.

In rare instances obstruction is caused by the growth of intrabronchial tumours.

Lastly, we may have stenosis by compression from pulmonary tumours or inflammatory growths, and at the root of the lung from enlarged lymphatic glands, aortic aneurysms, or oesophageal tumours.

For the consequences of bronchial obstruction as affecting the lung see Chapter LXXXIII.

581. **Hyperplasia and induration.** After long-enduring bronchial catarrh thickening and papillary overgrowth of the mucous membrane is sometimes though not frequently observed. The change is never extensive, and is of small importance.

The induration and thickening of the entire bronchial wall, which results from certain forms of inflammation, is much more important. The change is most frequently observed in the neighbourhood of plugs of inspissated secretion, though it occurs also in unobstructed tubes and sometimes extends over a considerable number of their ramifications It may also affect the peribronchial

fibrous tissue and even extend to the contiguous parenchyma of the lung. From what we may call endobronchitis is developed indurative mesobronchitis and **peribronchitis** with peribronchial lymphangitis.

Indurative peribronchitis may also arise from the like change (cirrhosis) commencing in the lung, the process either being of the nature of direct extension or advancing from the bronchioles of the



FIG. 218. INDURATIVE PERIBRONCHITIS

(*Section obtained with picrocarmine* × 4)

a bronchi, some of them dilated
b arteries
c thickened peribronchial fibrous tissue
d radiating bands of fibrous tissue
e thickened bronchioles blocked up with secretion
f fibroid indurations in which the bronchi have not been cut across
g thickened pleura
h pulmonary tissue, partly emphysematous

indurated parenchyma by way of the peribronchial lymphatics to the peribronchial fibrous tissue of the larger tubes. In like manner the inflammatory change may extend from inflammation of the pleurae or of the interlobular septa. In rare instances the induration extends from the fibrous tissue and lymphatic glands at the root of the lung, and proceeds radially along the peribronchial structures.

The appearance of a bronchus thus thickened and indurated varies greatly according to the way in which the process has been set up. If the tube is unobstructed (Fig. 218) it looks on section like a thick-walled aperture, sharply defined against the pulmonary tissue or surrounded by radiating fibrous bands (*d*), and projecting above the cut surface. If the tube is filled with inspissated secretion (Fig. 218 *e*, Fig. 217 *a*) the wall looks like a thickened capsule surrounding it. When the adjacent parenchyma of the lung is devoid of air, collapsed (Fig. 218 *e*), and indurated, there is no sharp line between the thickened bronchus and the altered lung: a slight difference in tint and in consistence is all that appears.

Inflammations issuing in suppuration or in caseation extend to the peribronchial tissues and lymphatics in the same way as the indurative variety: they often extend both widely and deeply.

In tuberculous bronchopneumonia with caseation caseous peribronchitis is always present, and in suppuration of the lung there is always a certain amount of purulent peribronchial lymphangitis. Of course the tubes immediately connected with the seat of disease in the lung are the first and most affected, but the process often spreads to the bronchi of other regions.

Peribronchitis being thus a secondary affection, and usually associated with bronchitic and pneumonic processes, it is always accompanied by changes in the lung or in the pleura (Fig. 218 *g*). Indeed these latter changes are frequently the most apparent, and overshadow to a great extent the peribronchial lesions (Art. 614). Cases however occur in which these are so marked that they form the essential character of the disease.

The term peribronchitis is used in the text in a much more restricted sense than is usual. Most writers include under it the nodular indurations of bronchopneumonia. It is thought best however to distinguish between the finer terminal or respiratory bronchioles, and those which serve simply as air-passages. The former are essentially elements of the parenchyma of the lung, and their inflammations are essentially pneumonic.

For references see Art. 582.

582. **Bronchiectasis** or dilatation of the bronchi results partly from increased internal pressure on the bronchial wall, partly from changes in its structure and in that of the surrounding pulmonary tissue.

The dilatation is either uniform and extending over one or more branches, or local and fusiform or saccular: it may be single

or multiple. Frequently we meet with several varieties of dilatation in the same patient.

Most frequently the dilatation is due to long-standing inflammatory affections by which the strength and elasticity of the bronchial wall is considerably diminished, so that it yields to the internal pressure of the respired air. Such dilatations are usually cylindrical, and are most marked in the lower lobes. When the wall yields unequally, the dilated tube appears sacculated, and its inner surface is irregularly corrugated with annular, oblique, or reticulate ridges and bands. These are simply the circular fasciculi of the bronchial wall, which retain to some extent their form in spite of the dilatation, the mucous membrane bulging and yielding between them. The mucous membrane is moreover more or less atrophied and infiltrated, the cartilages are often partially disintegrated and replaced by fibrous tissue, and the orifices of the mucous glands are dilated into small funnels. The epithelium is sometimes little altered; but in other instances it is seen that the columnar cells have become mucoid or detached, so that the surface is lined only with short cubical or club-shaped cells devoid of cilia. This is especially the case where there is much catarrh.

Bronchiectasis is especially apt to occur when the branches of an inflamed bronchus are partially impermeable to air, so that the corresponding portion of the lung is collapsed and functionless. The result is that on inspiration the air entering the bronchus is not uniformly distributed; and even if the neighbouring portions of the lung should dilate by way of compensation, as the thorax expands the air which rushes in is still unequally distributed and bears abnormally on the obstructed tube. Adhesions and thickenings of the pleura and of the interlobular fibrous tissue have often a like effect, inasmuch as they interfere with the equable expansion of the lung, and lead to irregularities in its distribution within the bronchi. Partial atelectasis (Art. 591) persisting after birth acts in the same way. When the pulmonary tissue round a bronchus undergoes contraction, it may in certain circumstances exercise traction on the bronchial wall and cause it to dilate. Lastly, when the bronchial secretion accumulates abnormally in an obstructed tube it may give rise to considerable distension and dilatation.

The bronchiectases brought about in the ways just enumerated are seldom fusiform or cylindrical. They are often saccular, globular, or irregular in form, or arranged in a moniliform series. Sometimes in an indurated lung they are so numerous that the latter appears excavated in all directions. In very rare instances we meet with regular cysts filled with mucus, behind a bronchial obstruction.

In these dilatations the mucous membrane undergoes changes similar to those just described.

Papillary outgrowths are very rarely met with. The exterior

layers of the bronchial wall, and the peribronchial fibrous tissue, are frequently much thickened, especially where there is inflammatory induration or cirrhosis of the lung. These are sometimes distinguished as hypertrophic bronchiectases.

References:—CORRIGAN, *Dublin Med. Journ.* 1838; BIERMER, *Virchow's Handb. d. spec. Path.* v, *Virch. Arch.* vol. 19; BUHL, *Lungenentzündung Tuberculose und Schwindsucht* Munich 1872; LEBERT, *Klinik d. Brustkrankheiten* I; TROJANOWSKY, *Beiträge z. Lehre von d. Bronchiectasie* In. Diss. 1864; FITZ, *Virch. Arch.* vol. 51; JURGENSEN, *Ziemssen's Cyclop.* IX; LICHTHEIM, *Arch. f. exp. Path.* X 1878; GRANCHER, *Gaz. méd. de Paris* 1878; LEROY, *Arch. de physiol.* 1879; CORNIL and RANVIER, *Man. Path. Hist.* II. London 1884; RIEGEL, *Ziemssen's Cyclop.* IV; HAMILTON, *Path. of bronchitis* London 1883; HELLER, *D. Arch. f. klin. Med.* XXXVI 1885.

Some authors (BIERMER, RIEGEL, RINDFLEISCH) state that in bronchiectasis the mucous membrane and the muscular coat frequently become hypertrophied and form papillary outgrowths, but this ZIEGLER has not been able to verify. The prominent ridges occasionally observed are not of new formation, but are simply those parts of the wall which have not yielded to the dilating forces.

583. **Ulceration** and **perforation** of the bronchial wall is due either to inflammation of the internal surface or to ulcerative affections in the surrounding tissues. Purulent, putrid, and tuberculous inflammations are those most apt to lead to ulceration and perforation from within (Art. 579).

Suppuration is especially likely to occur when septic matters are inhaled with the inspired air or when the bronchial secretion undergoes putrefactive changes. The latter takes place in bronchiectases, where the secretion is apt to linger for a considerable time.

When perforation occurs and the originating inflammation extends to the surrounding parts, the peribronchial tissue and the adjacent lung-tissue become infiltrated, and according to the character of the inflammation undergo caseous or suppurative and putrid disintegration. Caseous or purulent bronchitis thus issues in caseous or purulent peribronchitis, and a bronchiectasis becomes an ulcerated **bronchiectatic vomica**. The peribronchial excavation either lies beside the primary dilatation or surrounds it more or less completely.

The destruction of the bronchial wall is at first usually partial, but in time it becomes complete; and the bronchus then appears to open into and terminate at the cavity.

The walls of the cavity may appear gangrenous, caseous, or infiltrated and indurated, according to the mode in which it has arisen and the point of time at which the examination is made. Its liquid contents are puriform, putrid, or mixed with fragments of caseous detritus. The putrid liquid contains bacteria, and often spherules of leucin and needles of tyrosin and margarin.

The cavity usually increases in size, and that most rapidly when the process is suppurative or gangrenous; less rapidly when caseation takes place; and least rapidly when the lung is already

indurated by chronic inflammation. The destructive process may advance not only peripherally but also along the course of the peribronchial lymphatics: in this way suppurative and caseous peribronchitis are not infrequently set up.

Ulceration and perforation of the bronchi from without are associated with suppuration, gangrene, and caseation of the parenchyma of the lung: they are extremely common. Caseous or suppurating lymphatic glands, peribronchial tumours, and aneurysms, occasionally break through the bronchial wall.

When a bronchus is thus perforated the broken-down tissues and detritus pass into its lumen and are either coughed up or aspirated into other parts of the lung. Air on the other hand may enter the excavation from the bronchus.

On the **tumours** of the bronchi see Art. 619.

CHAPTER LXXXI.

STRUCTURE AND FUNCTION OF THE LUNGS.

584. The **parenchyma of the lung** is composed essentially of the terminal bronchioles and alveoli and of blood-vessels, together with a certain amount of connective tissue which unites the ultimate branches of the bronchi into lobules and marks them off one from another.

The transition from the air-tubes to the respiratory parenchyma is very gradual, the bronchial walls changing in structure by slow degrees and ultimately becoming sacculated. The bronchi subdivide dichotomously into ever finer branches, and it is the finest terminal branches or bronchioles which go to form the respiratory parenchyma. At first the sacculations or **alveoli** occur singly (Fig. 219 *B*), and then in small groups on one side of the bronchiole.



FIG. 219. TERMINATION OF A BRONCHIOLE AND OF A PULMONARY ARTERIOLE. (*Prepared by corrosion: magnified by a hand-lens*)

A bronchiole *B* pulmonary arteriole

The tubes which are thus partially transformed into respiratory tissue are known as **respiratory bronchioles**. Each respiratory bronchiole divides into two or three smaller branches, which are surrounded on all sides by alveoli (*B*) and are known as **alveolar ducts**. The terminal alveoli are called **infundibula**.

As the smaller bronchi pass into the respiratory bronchioles they alter notably in structure. The cartilages disappear, and the epithelium is reduced to a single layer of low non-ciliated cells, which ultimately take the form of broad polygonal pavement cells (KOLLIKER).

As the respiratory bronchiole changes to an alveolar duct these modified columnar cells in turn disappear, and the epithelium takes the form of small nucleated granular-looking pavement cells interspersed with larger hyaline plates some with and some without nuclei. The muscular fibres of the bronchioles persist as annular bands surrounding the orifices of the lateral alveoli and of the terminal infundibula.

The epithelium of the alveoli is like that of the alveolar ducts. Their walls consist of a delicate membrane strengthened by scattered filaments and bundles of elastic tissue. They are devoid of muscular fibres.

The clustered alveoli belonging to each bronchiole are not quite contiguous, but are separated by spaces which are filled by other groups of alveoli and infundibula. The contiguous groups are bound together by connective tissue.

In preparations made by maceration or corrosion the alveolar ducts of each bronchiole appear thus to stand apart from each other; while in sections (Fig. 220) the alveolar tissue looks like a continuous meshwork, interspersed with transverse and longitudinal

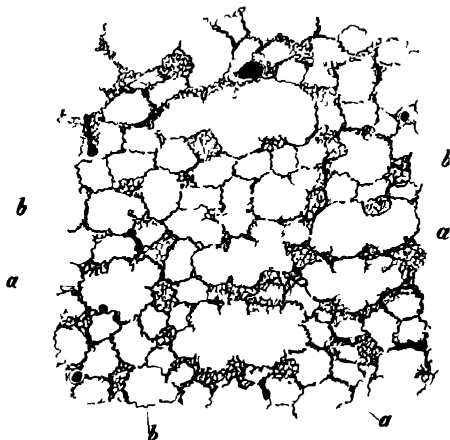


FIG. 220. SECTION OF AN INJECTED HEALTHY LUNG (×20).

a longitudinal, *b* transverse sections of respiratory bronchioles, alveolar ducts, and infundibula.

sections (*a*, *b*) of bronchioles, alveolar ducts, and infundibula. At the boundaries of the several bronchiolar systems we find broader bands of connective tissue marking off the so-called **lobules**.

The pulmonary parenchyma derives its blood-supply almost entirely from the **pulmonary artery**. Its capillaries surround the walls of each air-cell or alveolus (Fig. 220), and their loops project into its cavity covered only by the thin epithelial lining. The terminal branches of each arteriole are not distributed to a single bronchiolar system only (Fig. 219 *A*), but supply several contiguous systems: they anastomose freely with the branches of neighbouring arterioles (Fig. 220) and form a continuous network of vessels. The blood from the capillaries is collected into **interlobular veins** which run between the several arterial areas.

The **lymphatics** arise in clefts and spaces lying in the inter-alveolar septa. The radicles unite and run in the peribronchial and circumvascular tissue, or in the interlobular, subpleural, and pleural connective tissue. Both bronchi and arteries are very richly supplied with lymphatics.

Throughout the whole lymphatic system of the lung we meet with collections of lymphoid cells (FRIEDLANDER, ARNOLD, KÖLLIKER), which are either round or fusiform. In children these lymphadenoid patches contain large numbers of cells, but in adults they are often more fibrous and pigmented. The pigment is enclosed in round, fusiform, or stellate cells, or it may lie free between them.

References :—Text-books of normal histology such as *Quain's Anatomy* II London 1882, KLEIN'S *Elements of Histology* London 1883; FRIEDLANDER, *Virch. Arch.* vol. 68; ARNOLD, *ibid.* vol. 80; KOLLIKER, *Zur Kenntniss d. Baues d. Lunge* Wurzburg 1881; KLEIN, *Anatomy of the lymphatic system* London 1875; FEUERSTAK, *Ueber d. Verhalten d. Epithels bei d. fibrinosen Pneumonie* Göttingen 1882; KUTTNER, *Die Kreislaufsverhältnisse d. Saugethierlunge*, *Virch. Arch.* vol. 73; COHNHEIM and LITTEN, *ibid.* vol. 65; ZUCKERKANDL, *Ueber Verbind. zwischen den art. Gefassen d. menschl. Lunge*, *Wiener Sitzungsberichte* LXXXVII.

The pulmonary artery is distributed almost entirely to the parenchyma of the lung, but it also according to KUTTNER gives off small branches to the subpleural and interlobular connective tissue and to the bronchial mucous membrane. The pulmonary arterioles are terminal, but by dilatation of the communicating capillaries connexions between neighbouring arterial territories are readily established and perform the function of anastomoses.

The branches of the bronchial arteries subdivide with the bronchi and supply these and their nerves and lymphatic trunks. Their capillaries are connected with those of the pulmonary artery. The vessels which reach the lung from the mediastinal pleura supply the subpleural and interlobular lymphatics, but they also communicate with the pulmonary and bronchial arterial systems.

585. The **morbid affections** of the lung originate in the vascular system or in the bronchi, or are extensions by contiguity from neighbouring parts.

The affections starting in the vascular system, that is to say

on disturbance of the circulation or disorder of the blood, make their first appearance in small patches corresponding to the territory of an arteriole, or they at once extend over a whole lobe, or over one or both lungs. In each case the extent and distribution of the local change is independent of the disposition and configuration of the smaller air-tubes.

With regard to affections of bronchial origin it must be noted that mere disturbance of the influx or efflux of respired air may give rise to grave changes in the pulmonary parenchyma. Impurity of the respired air is a still more potent cause of disease, as it leads not merely to morbid deposits in the lung but also, and very frequently, to inflammatory change. This latter is always at first localised, and often over areas corresponding precisely to the distribution of the bronchioles.

Disease of parts contiguous to the lung, and especially of the pleura, often give rise to pulmonary injury by the hindrance or obstruction of the respiration which they cause. In other cases the morbid process itself extends from the surrounding tissues to the lung, and usually spreads along the course of the lymphatic channels.

Malformations of the lung are on the whole not common. Absence of one or both lungs only occurs in cases where there are other grave defects of development. Absence of parts, abnormal smallness, etc., are met with in connexion with malformation or deformity of the thorax. A small accessory lung unconnected with the trachea has once or twice been observed.

The commonest anomaly, and one which has no functional significance, is multiplication of the lobes.

In some of the lobes or in parts of them the air-tubes are occasionally absent or ill-developed, and then the corresponding part of the parenchyma consists simply of continuous cellular and highly vascular fibrous tissue. The bronchi leading to the airless tissue may be more or less dilated (Art. 582).

On the other hand we sometimes find in one or more parts of the lung large vesicular cavities resembling excessively distended alveoli.

On congenital malformations of the lungs see FÜRST (*Gerhardt's Handb. d. Kinderkrankheit.* III), ROKITANSKY (*Path. Anat.* IV (Syd. Soc.) London 1852), MAYLARD, and L. HUMPHRY (*Journ. of Anat. and Physiol.* 1885), EDWARDS (*Amer. Journ. med. sci.* 1885).

CHAPTER LXXXII.

DISORDERS OF CIRCULATION IN THE LUNG.

586. **Congestive hyperaemia** may be due to diminution of the normal resistances to the arterial current within the lung, and may be induced by direct stimuli reaching the lung through the respired air, as when irritating or irrespirable gases are breathed or when the air is excessively hot or excessively cold. It is also the first step to inflammation. Partial or collateral congestion of one part of the lung sometimes results from obstruction of an important arterial branch in another part.

Congestion of the lung, when it is not collateral or due to local textural or vascular change (as in inflammation), extends uniformly over the whole organ. It is usually transient, and is very seldom fatal. In the fatal form of congestion called vascular **pulmonary apoplexy**, the lung appears swollen and abnormally firm, of a uniform dark-red colour on section, and containing but little air; the capillaries are everywhere distended with blood and encroach on the alveolar cavities. There are usually some scattered extravasations of blood.

Engorgement or passive hyperaemia results from hindrance or obstruction to the outflow of blood through the pulmonary veins, or from causes tending to weaken the propelling forces. The latter appear when the activity of the right heart is impaired, when the pulmonary artery or its branches are obstructed, or when the respiration is interfered with. Thus when (as in suffocation) the inspiratory muscles dilate the thorax while air is prevented from entering the lungs, blood is as it were pumped from the extra-thoracic vessels into the intra-thoracic, and the blood collects and stagnates as it does under a cupping-glass.

Obstruction to the outflow of blood from the lung is most frequently caused by valvular lesions of the left heart; but the same effect is also indirectly produced by obstructive increase of pressure within the aorta which the heart is at length unable to overcome, and by relaxation or degeneration of the wall of the left ventricle.

Failure of the propulsive power of the heart causes engorge-

ment chiefly of the dependent parts of the lung (**hypostatic engorgement**): arterial obstruction causes *hyperaemia of the region supplied by the artery* (Art. 589), and *interference with respiration causes hyperaemia of the lobules which are prevented from acting* (Art. 591). When the engorgement is great the affected parts become purple or livid in colour.

Passive hyperaemia may give rise to various secondary changes, such as haemorrhage, oedema, dilatation of vessels, and loss of epithelium.

Anaemia of the lung may be due to general anaemia. When it is partial it is usually dependent on compression or excessive inflation of the part. After death the blood generally flows from the anterior portions of the lung to the deeper and posterior portions.

587. When in consequence of endocarditis and valvular thrombosis the mitral orifice is rapidly obstructed and the valve rendered incompetent, the backward pressure and consequent engorgement in the pulmonary veins is apt to be very great, and oedema, haemorrhage, and epithelial desquamation ensue.

The **oedema** is marked by the escape of serous liquid into the alveoli (Art. 588), but in this variety the quantity of liquid is seldom great. The extravasation of blood also is not usually considerable, though there are here and there small haemorrhages recognisable even with the unaided eye: the extravasated blood may fill the alveoli to the exclusion of air.

The epithelial desquamation is sometimes slight, but in other cases it is so abundant that the alveoli are all but filled with granular or homogeneous epithelial plates. The lung then looks greyish-red, and is abnormally firm to the touch: it contains little air, and in places may be entirely airless. The desquamation of epithelium is due to the transudation of lymph from the capillaries.

Mitral disease of long standing, when accompanied by hypertrophy of the right ventricle and permanent increase of pressure within the pulmonary vessels, leads to the condition known as **brown induration** of the lung. The organ is larger and firmer than usual, it contains less air, and its tissue is brownish-red and dry, or rarely oedematous. It often contains scattered haemorrhagic patches and spots of brown.

The principal changes are dilatation of the vessels and pigmentation of the tissues. The dilatation is most marked in the capillaries, which protrude into and encroach on the alveolar spaces.

The **pigmentation** of the lung is due to the presence of yellow and brown granules deposited chiefly along the course of the lymphatics in the peribronchial, circumvascular, and interlobular tissues, and also to some extent in the alveolar walls. The granules are enclosed in stellate, fusiform, or rounded cells or lie free in the tissues. The alveolar epithelium is here and there pigmented.

The pigment is derived from the blood. When blood escapes

from the vessels the alveoli are at first more or less filled with it. Part of it passes directly into the lymphatics which communicate with the lumen of the alveoli. Another portion disintegrates within the alveoli, and at the same time white blood-cells migrate from the capillaries and take up the disintegrated matters, becoming thus transformed into corpuscle-carrying and pigment-granule cells. These lie at first within the alveoli and are sometimes met with in great numbers. Thence they may pass into the bronchi and are coughed up, but the greater number pass into the lymphatics and so reach the lymphatic glands, or remain lodged in the tissues of the lung, especially in the patches of lymphadenoid tissue. The detritus of the blood which passes directly into the lymphatics lodges in the same parts; the ultimate form which it takes being in all cases that of brown or even black pigment.

When the engorgement and excessive pressure persist for a long time the walls of the pulmonary vessels become hypertrophied, and the connective tissue is also somewhat increased. According to RINDFLEISCH and others the muscular fibres of the bronchi and alveolar ducts are also hypertrophied.

References :—DITTRICH, *Beitr. z. path. Anat. d. Lungenkrankheiten* Erlangen 1850; VIRCHOW, *Virch. Arch.* vol. 1; ZENKER, *Beitr. z. norm. u. path. Anat. d. Lungen* Dresden 1862; BUHL, *Virch. Arch.* vol. 16; RINDFLEISCH, *Path. Hist.* II London 1873; HERTZ, *Ziemssen's Cyclop.* V; ORTH, *Virch. Arch.* vol. 58; EBERTH, *ibid.* vol. 72.

588. **Oedema** of the lung is a condition in which the alveoli and bronchioles, and often the bronchi also, are filled with serous liquid more or less mingled with air. The condition may extend over the whole lung, or only over a lobe or part of a lobe. The pulmonary tissue may be either anaemic or hyperaemic.

Pulmonary oedema arises in various ways. It generally appears *in articulo mortis* as a result of the gradual failure of the heart. According to COHNHEIM it occurs when the outflow through the pulmonary veins is opposed by an obstruction that the right ventricle cannot overcome. This is the case when from weakness or excessive aortic resistance the left ventricle fails to empty itself in systole. COHNHEIM'S explanation is based on experiment and no doubt applies to many cases of ante-mortem oedema, but not to all.

Not infrequently the signs of previous engorgement are entirely absent, and the distribution of the oedema is so irregular that we cannot refer it to a condition (like engorgement) extending over the whole lung. In such cases we must assume that we have to do with some alteration of the vessel-walls that causes them to be abnormally permeable, and is referable to the disease from which the patient has suffered. The like explanation will apply to the oedema which occasionally results from the breathing of irrespirable gases.

Another variety is the inflammatory oedema which generally accompanies certain inflammatory processes, such as croupous or suppurative inflammation. Lastly, multiple fat-embolism of the

pulmonary arterioles may give rise to oedema from obstruction of the capillary circulation.

The liquid of pulmonary oedema is always albuminous, and usually poor in cellular elements derived from the blood. The oedema of engorgement not rarely is due to liquid which contains red blood-cells, often in such abundance as to give it a haemorrhagic appearance.

Epithelial cells are sometimes abundant in the liquid, sometimes scanty: they are more or less swollen up. If catarrh is present at the same time, numbers of white blood-cells mingle with the liquid. Where pigmentation of the lung is in process some of these cells contain pigment-granules.

References :—COHNHEIM, *Allg. Path.* I Berlin 1882; WELCH, *Virch. Arch.* vol. 72; POSNER, *ibid.* vol. 79; FALK, *ibid.* vol. 91; S. MAYER, *Wiener Sitzungsber.* LXXVII 1878, *Prager med. Woch.* 14, 1880; LITTEN, *Berl. klin. Woch.* 1882.

589. **Haemorrhage** from the pulmonary vessels is of very common occurrence and arises from a great variety of causes.

In the first place haemorrhage is very frequently a result of engorgement, especially that due to violent inspiratory efforts with obstructed access of air (inspiratory dyspnoea). The quantity of blood which escapes is not usually so great as to cause firm haemorrhagic infarction, but it may lead to the formation of rather large dark-brown patches of infiltrated and airless tissue.

When a large quantity of serous liquid transudes with the red blood-cells we have what is called haemorrhagic oedema of the lung.

When the air is entirely displaced from the lung-tissue, so that it becomes dark-red and not unlike a soft and very vascular spleen, the condition has been termed **splenisation** of the lung. It is most commonly a result of gradual cardiac paralysis before death: the blood no longer efficiently propelled accumulates in the deeper parts of the lung and so gives rise to what we might describe as hypostatic haemorrhagic oedema. If as often happens inflammation begins in the engorged region the process is termed **hypostatic pneumonia**.

Extravasation of blood is an exceedingly common accompaniment of pneumonic and bronchopneumonic affections (Arts. 602, 613).

In acute inflammations the red blood-cells escape from the vessels with the inflammatory exudation, of which indeed they form a component part. In the later stages of the inflammation, when the pulmonary tissue breaks down, haemorrhage is usually due to the rupture of small or large blood-vessels whose walls have been softened or ulcerated through.

In the case of the larger arterial branches the wall usually yields and becomes dilated into a small **aneurysm** before actual rupture. These aneurysms are most frequently observed on vessels which traverse or lie in the wall of ulcerating cavities. When

they rupture more or less copious haemorrhage ensues, and the cavities together with the bronchi which open into them are flooded with blood.

Mechanical injury, like that caused by a bullet or a broken rib, gives rise to bleeding whose amount depends of course on the nature and extent of the wound.

In somewhat rare cases pulmonary haemorrhage is referable to a congenital or acquired haemorrhagic diathesis, as in haemophilia, in purpura, or in scurvy; or to infective diseases like scarlatina, typhoid, and small-pox; or lastly to cerebral disease, especially such as causes disturbance of the respiratory function. In the latter case the bleeding may be very considerable, whole segments of the lung becoming infiltrated and airless.

The most marked form of **haemorrhagic infiltration** or **infarction** is that which follows thrombosis or embolism of a branch of the pulmonary artery. The infarct is usually subpleural, of a sharply defined conical form, and in the recent state dark brownish-red in colour and firm in consistence. When the blood is somewhat leukaemic the infarct may be greyish-red or greyish-white in colour. The emboli come from the right side of the heart or from the systemic veins and usually lodge at the bifurcation of the arterial branches. The characteristic extravasation takes place when the blood reaching the embolised region from the neighbouring capillaries is insufficient to maintain the circulation.

Pulmonary infarcts vary in size from that of a cherry-stone to that of a hen's egg, though occasionally they are much larger. The pleura over a recent infarct is smooth and glistening, but afterwards it becomes turbid and covered with a thin fibrinous film.

Embolism of a pulmonary arteriole is not always followed by haemorrhagic infarction, though the arteries are *terminal* in COHNHEIM'S sense of the word (Art. 30). Sometimes of course death ensues before there is time for the formation of an infarct, but apart from this the circulation may be maintained by the free influx of blood from the neighbouring capillaries.

References on haemorrhagic infarction of the lung:—VIRCHOW, *Gesammelte Abhandl.* Frankfort 1856; COHNHEIM, *Allg. Path.* I Berlin 1882; PANUM, *Virch. Arch.* vol. 25; WILLIGK, *Prager Vierteljahrsschrift* L; GERHARDT, *Sammlung klinischer Vortrage* 91, *Gerhardt's Handb. d. Kinderkrankh.* III; HAMILTON, *Liverpool med. chir. Journ.* 5, 1883; LITTEN, *Berl. klin. Woch.* 1882.

References on pulmonary haemorrhage in cerebral disease:—PINEL, *De l'hémorrhagie pulmonaire en rapport avec les lésions du cerveau* Thèse de Paris 1876; NOTHNAGEL, *Cent. f. d. med. Wiss.* 1874; JEHN, *ibid.*; BROWN SÉQUARD, *Lancet* 1, 1871; CHARCOT, *Leçons sur les maladies du syst. nerv.* Paris 1875; CARRÉ, *Archives générales* 1877.

590. Blood extravasated into the tissue of the lung is re-absorbed provided the tissue remains otherwise uninjured (Art. 587). The corpuscles dissolve and are taken up in solution, or they break up and pass, either free or enclosed in cells, into the lymphatics. Thence they are carried to the lymphatic glands, or are deposited in the walls of the lymphatic vessels, and give rise to black or

brown pigmentation. Some of the cells containing disintegrated blood are removed with the sputum. During the stage at which the lymphatics and the alveoli contain a large amount of disintegrated blood the pulmonary tissue has a dirty orange or rusty tint.

In more copious haemorrhage, such as follows the rupture of an artery, blood passes into the bronchi and is coughed up (**haemoptysis** or haemoptoë). Some of the blood may be aspirated from the bronchi into neighbouring branches and into their alveoli. In this way haemorrhagic patches exactly resembling primary haemorrhages are formed; usually however their number and distribution, and the circumstances in which they occur, enable us to discern their nature.

The firm haemorrhagic infarct becomes rapidly decolorised, assuming a reddish-brown or rusty tint. Then a reactive inflammatory immigration of leucocytes sets in from the vessels of the contiguous parts, and accelerates the re-absorption of the blood. In the course of time such infarcts often disappear entirely, leaving no permanent structural change behind. In other cases the affected region is indicated by a more or less marked but seldom very definite condensation of the pulmonary tissue, with some cicatricial contraction; the pleural surface of the region is slightly drawn in, and shows a certain amount of fibroid thickening with white radiating bands extending from it. The condensed tissue is sometimes brown or slate-coloured, sometimes undistinguishable in colour from the surrounding tissue. The condensation is due partly to collapse of the infiltrated alveoli, partly to new-formation of fibrous tissue in the alveolar septa by which they are thickened and bound together into a compacter mass.

The embolus is meanwhile absorbed in like manner, its place being indicated by slight corrugations of the wall or filaments traversing the lumen of the artery.

When the infarct is large or the re-absorption of the extravasated blood and the re-establishment of the circulation delayed, part of the infiltrated tissue may perish and break down into an inodorous brownish-red pulp: this either makes its way into a bronchus and is so removed, or is re-absorbed. The loss of substance is repaired by the development of cicatricial tissue, provided no septic change is set up within the cavity.

In rare instances the re-absorption of blood and disintegrated lung-tissue is incomplete, and the detritus remaining passive for a time becomes thickened and caseous, and at length calcified, the whole being enclosed in a capsule of new-formed fibrous tissue.

When the embolus causing the infarction contains at the same time infective matters capable of setting up decomposition or suppuration, or when these reach the injured tissue with the inspired air, we may have gangrene or suppuration of the lung (Art. 605).

CHAPTER LXXXIII.

ATELECTASIS, COLLAPSE, AND EMPHYSEMA OF THE LUNG.

591. In the unborn child the lung is a compact structure, the alveoli exist potentially, but they are everywhere collapsed and airless. When respiration commences the alveoli become distended with air into hollow vesicles and the epithelial lining of their walls becomes expanded and flattened.

If the respiration is imperfect owing to the occlusion of a bronchus or the compression of some part of the lung, some of the lobules remain unexpanded and retain the dense fleshy consistence and livid tint of the foetal organ. This condition is known as **foetal atelectasis** or **apneumatosis.**

When a part of the lung which has once acted becomes from any cause airless it is said to be **collapsed** or atelectatic. The condition may be due to compression, or to obstruction of a bronchus. Compression of the lung is most commonly brought about by the collection of air or liquid in the pleural cavity, or by excessive elevation of the diaphragm: it may also be due to aortic aneurysm, spinal curvature, thickening and contraction of the pleura, distension of the pericardium, etc. The compression may be partial or total, and the collapse may be more or less complete.

When the collapse affects the whole lung and is complete, the organ is usually squeezed up against the spine, and its tissue is dense, tough, and airless: its colour is generally pale pink or grey. Collapsed segments of the lung have a similar appearance, but there is often more blood in the part and so it has a redder colour.

When a bronchus or bronchiole is occluded by secretion or other cause, the corresponding segment always becomes airless after a time. LICHTHEIM states that the oxygen of the enclosed air is first absorbed by the blood, then the carbonic acid, and ultimately the nitrogen; the lung shrinking to its foetal condition.

As the collapsed part no longer expands or contracts with respiration, and its capillaries are much folded and contorted, a certain amount of engorgement takes place. The unexpanded tissue thus looks somewhat livid in tint, and is retracted or sunken in comparison with the normal tissue.

Obstructive collapse is extremely common and is indeed a usual accompaniment of inflammation of the smaller bronchi. *Post mortem* the lung looks mottled with livid retracted patches alternating with pink or reddish-white air-containing regions.

References :—WEBER, *Beiträge z. path. Anat. d. Neugebornen* Kiel 1852 ; BARTELS, *Virch. Arch.* vol. 21 ; HERTZ, *Ziemssen's Cyclop.* v ; GERHARDT, *Virch. Arch.* vol. 11, and *Gerhardt's Handb. d. Kinderkrankh.* III ; LICHTHEIM, *Arch. f. exp. Path.* x ; TRAUBE, *Gesamm. Beitrage z. Physiol. u. Path.* Berlin 1871 ; BALZER, *Gaz. méd. de Paris* 1878 ; ROMELAERE, *De l'atélectasie pulmonaire* Brussels 1881 ; SCHUCHART, *Virch. Arch.* vol. 101.

592. **Results of collapse.** When a part of the lung remains collapsed for some time certain changes in its tissues usually make



FIG. 221. CIRRHOSIS FROM COLLAPSE OF THE PULMONARY TISSUE.

(*Horizontal section through the apex of the lung, stained with picrocarmine and mounted in Canada balsam:* × 5)

bronchi plugged with secretion
obliterated bronchioles
small bronchus distended with secretion

d pulmonary arterioles
e collapsed indurated pulmonary tissue
f normal, *g* emphysematous pulmonary tissue

their appearance. Small haemorrhages take place from the engorged vessels, by which the tissue becomes permeated by blood-cells

and to some extent pigmented: it is however beyond doubt that much of the black pigment which is ultimately deposited in the collapsed tissue is simply dust and carbonaceous matter inhaled before the bronchi became occluded. Presently the alveolar septa cohere and coalesce, and the tissue is transformed into a more or less compact and continuous mass (**carnification**).

The cohesion of the alveolar walls and the consequent condensation and induration of the tissue probably never take place without some slight inflammation, which is either conducted from the inflamed bronchi or set up by the extravasated blood. After a time but few remnants of pulmonary structure can be made out in the collapsed region, and in them the septa are thickened, the few shrunken alveoli are filled with cells, and the epithelium for the most part lost. Other parts (Fig. 221 *e*) consist of dense and compact fibrous tissue, usually much pigmented and resembling black india-rubber.

This condition we may call the **cirrhosis of collapse**: from the pigmentation which is always present it is often referred to as **grey induration**.

It is most common about the apex of the lung (Fig. 221), where catarrhal obstruction of the bronchi (*a*) frequently takes place and leads to the collapse of the corresponding alveoli with the changes just described.

The occluded bronchi are often hypertrophied (*a*) and distended with the accumulated secretion (*c*). The small respiratory bronchioles (*b*) are nearly all obliterated.

The surface of the condensed portion is always shrunken and distorted, and there are generally adhesions between the pleural surfaces which show that at some time or other inflammation has existed about the parts.

The pulmonary tissue lying between the collapsed regions is partly normal (*f*), partly emphysematous (*g*); it often includes small islands of collapsed and indurated tissue (*e*). The bronchi which are still pervious to air are not infrequently dilated (Art. 582).

When part of the lung persists in a state of foetal atelectasis, the pulmonary tissue is by degrees transformed into compact unpigmented fibrous tissue, sometimes interspersed (HELLER, FEUSTEL) with bits of cartilage and adipose tissue, the obliterated alveoli being represented by a few clusters of epithelial cells. The corresponding bronchi are in general somewhat dilated, so that the unpigmented tissue is traversed by smooth-walled channels and cavities of various sizes: in particular instances these may be as large as a hen's egg. The cavities are lined with cylindrical epithelium, and like other bronchiectases may be the seat of inflammatory change.

HELLER (*Naturforscherversammlung in Freiburg* 1883, *D. Arch. f. klin. Med.* XXXVI 1885) and FEUSTEL (*Ueber die späteren Schicksale der Atelektase*

In. Diss. Kiel 1883) have recently directed attention to the bronchiectasis which may follow upon foetal atelectasis. ZIEGLER has met with a typical example in the case of a man of 35, in whom about a quarter of the upper lobe of the left lung was transformed into dense white fibrous tissue, excavated in all directions by smooth-walled cavities lined with cylindrical epithelium and communicating with bronchi. The largest cavity was about as large as a hen's egg. There were no signs whatever of any previous inflammation.

593. When the thorax is over-distended by forced inspiration, or when one part of the lung is pervious to air while another part is shut off, the pervious parts become excessively inflated and a condition which we may describe as **acute vesicular emphysema** is induced. The alveoli are not altered in structure but are simply over-distended. This condition is very commonly the result of bronchopneumonia. The distended lobules are pale and anaemic, and those that lie immediately beneath the pleura project like little blebs above the level of the normal or atelectatic parts.

When the pressure within an alveolus exceeds a certain amount its wall gives way, and air enters the interalveolar tissue and especially the lymphatic channels. This condition is called **inter-vesicular emphysema**. It is generally a result of bronchitis or bronchopneumonia accompanied by violent coughing, and is met with in children who have died of asphyxia during the course of these affections. It has also occurred from over-energetic attempts to insufflate the lungs of stillborn infants.

The alveoli of the anterior border of the upper lobe are the most apt to give way. The inflated vesicles are usually subpleural and may be as large as a pea. Sometimes air passes from them under the pleura towards the root of the lung and into the mediastinal adipose tissue, sometimes even inflating the subcutaneous structures of the neck and thorax (**subcutaneous emphysema**).

594. When the alveoli are subjected to persistent or often-repeated distension, partial atrophy and yielding of their walls ensue, and two or more alveoli being thus converted into one the pulmonary tissue is to that extent 'rarefied.' This state is called **chronic vesicular emphysema** or simply emphysema. Its production may be facilitated by disorders of nutrition, such for example as accompany local inflammation or senile decay. The lungs of many persons seem also normally to possess but little power of resistance to over-distension.

The atrophy of the septa begins at the point where they are thinnest, and first appears in the widening of the intercapillary spaces (Fig. 222 *a*) and the yielding or disappearance (*b*) of the elastic fibres. Holes and gaps next appear between the capillaries in the septa; they are at first very small (*b*), but soon enlarge (*d*). The over-stretched capillaries become impervious (*c*) and ultimately give way (*d*).

By the gradual extension of this process many of the septa and

their capillaries at length disappear, the thicker fibrous bundles which surround the alveolar ducts being the last to go.

The epithelium is passive throughout and often shows signs of degenerative (especially fatty) change. Sometimes the tissue is

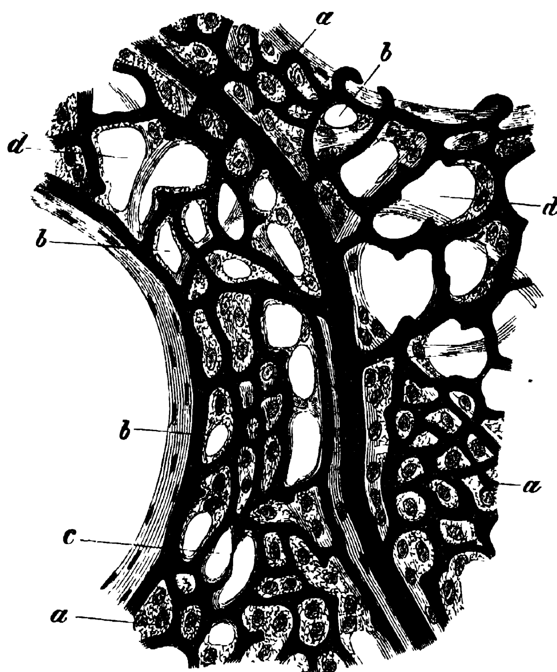


Fig. 222. Chronic vesicular emphysema.

(*Injected preparation, stained with carmine and mounted in Canada balsam:* × 200)

a dilated intercapillary spaces with epithelial cells
b gaps in the alveolar septa (Eppinger's primary dehiscence)
c capillary in process of obliteration
d larger gaps in the alveolar septa and in the capillary network (Eppinger's secondary dehiscence)

inflamed and infiltrated, but this has nothing to do with the emphysema as such; it is simply a concomitant of the catarrh which so frequently affects patients suffering from emphysema.

Chronic emphysema may be due, like the acute variety, to persistent inspiratory over-distension of the lung-tissue. This occurs chiefly in cases where parts of the lung are collapsed and functionless (Art. 592), and the neighbouring parts (Fig. 221 *g*) are accordingly over-distended. We might describe this as vicarious or compensatory emphysema. It is sometimes lobular, sometimes lobar in its extension. The emphysematous lobules are inflated and the alveoli abnormally large.

On the other hand emphysema also results from persistent and violent expiratory efforts, in conditions which interfere with the egress of air from the alveoli, ingress being unimpeded. This is

the case in the important variety described as chronic idiopathic diffuse emphysema or simply **general emphysema**, an affection which is very common in persons subject to chronic bronchial catarrh or to frequently-recurring expiratory dyspnoea, or obliged to make violent expiratory efforts in connexion with their employment.

This form of emphysema extends over the whole lung, though it is usually most marked at the edges and apices of the lobes, and at the base. When the lung is removed from the thorax it appears abnormally large, its edges obtuse and rounded, and the base frequently studded with hemispherical bladder-like prominences. The air-vesicles are everywhere enlarged by the disappearance of interalveolar septa, sometimes so much so that they look like bullae and range in size from that of a pea to that of a hen's egg. The latter is chiefly the case at the edges and base, and there as a rule only in the lung-tissue immediately beneath

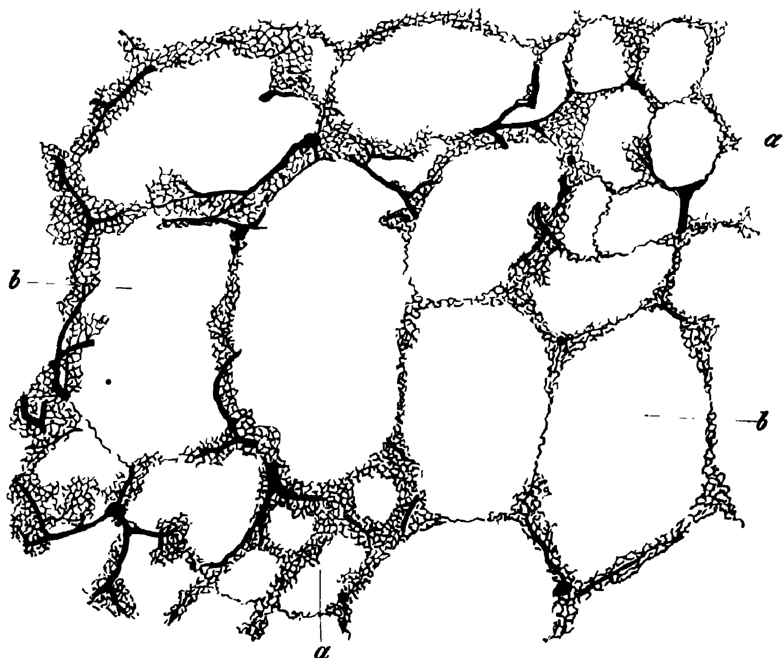


FIG. 223. RAREFIED PULMONARY TISSUE IN EMPHYSEMA.

(*Injected preparation:* × 20)

a infundibular vesicles produced by disappearance of interalveolar septa
b larger vesicles produced by coalescence of infundibular vesicles

the pleura. The smaller vesicles (Fig. 223 *a*) are formed by the disappearance of the interalveolar septa belonging to a single infundibulum; the larger vesicles (*b*) to the disappearance of the partitions between adjacent infundibula.

When there is much atrophy of the parenchyma the distended lung feels remarkably soft and downy, and its edges are markedly translucent. If the air is pressed out the lung becomes a mere flaccid inelastic mass with membranous edges.

Chronic idiopathic emphysema is occasionally limited to a part of the lung, usually to the edges. In this case the expiratory obstruction has obviously been also local.

When some of the vesicles in the general or in the local form are of exceptional size we have what is called **bullous emphysema**. The air is usually not easily pressed out of the larger vesicles.

The above account refers the production of emphysema chiefly to mechanical causes, namely to abnormal distension of the alveolar walls; but the atrophy of the latter may be much accelerated by malnutrition or senile decay of the pulmonary tissue In senile emphysema the latter factor is of essential importance, though the mechanical factors must not be entirely overlooked.

In emphysema a large number of capillaries are obliterated, and the vascular area of the pulmonary artery being thus contracted the resistance to the circulation through it is increased. Compensatory hypertrophy of the right ventricle is thus a frequent concomitant, while the pulmonary arterioles that remain are often visibly dilated.

References:—JENNER, *Med. chir. Trans.* XI 1857; BIERMER, *Sammlung klin. Vorträge* 12, *Virchow's Handb. d. spec. Path.* V; KNAUTHE, *Schmidt's Jahrbücher* vol. 163; HERTZ, *Ziemssen's Cyclop.* V; LICHTHEIM, *Arch. f. exp. Path.* X 1878; EHEBALD, *Deut. med. Woch.* 1881; RIEGEL and EDINGER, *Zeitschr. f. klin. Med* 1882–83; VILLEMIN, *Arch. gén. de méd.* 1866; BAYER, *Arch. d. Heilk.* II; THIERFELDER, *Atlas d. path. Hist.* I (Plate VI); EPPINGER, *Viertelj. f. prakt. Heilk.* vol. 132.

CHAPTER LXXXIV.

DEGENERATIONS OF THE LUNG.

595. The **non-inflammatory degenerations** of the pulmonary tissue are of comparatively slight importance, and have no practical interest for the physician. Emphysema and senile atrophy may form nominal exceptions, and they have already been discussed in Art. 594.

Swelling, fatty degeneration, and desquamation of the pulmonary epithelium accompany every copious transudation into the alveoli, inflammatory or non-inflammatory. The inhalation of deleterious substances also leads to manifold injury of epithelium, blood-vessels, and fibrous stroma; but the changes so induced are of altogether secondary importance in comparison with the inflammation which is at once set up.

Among degenerative changes due to disorders of nutrition we may mention fatty degeneration of the epithelium and amyloid degeneration of the fibrous structures. The former occurs in emphysema and in poisoning by phosphorus and arsenic, the latter in conditions which lead to the like change elsewhere. It is however to be kept in mind that the lung is on the whole but rarely the seat of amyloid change, and that the walls of the blood-vessels are most apt to be affected.

Calcification of the fibrous stroma of the lung is rare, except in cases where the tissue has been morbidly altered by antecedent inflammation.

References :—BUHL, *Lungenentzundung Tuberculose u. Schwindsucht* 1873 (fatty and amyloid change); CORNIL and BRAULT, *Journ. de l'anat. et de la physiol.* XVIII 1882 (phosphorus and arsenic poisoning); CORNIL, *Arch. de physiol.* 1874 (hyaline degeneration); ZAHN, *Virch. Arch.* vol. 72 (stratified corpora amylacea); VON RECKLINGHAUSEN, *Allgem. Path.* Berlin 1883 (ditto); CHIARI, *Wien. med. Woch.* 1, 1878 (calcification); HLAVA, *Wien. med. Blätter* 36, 1882 (calcification of pulmonary vessels); ORTH, *Lehrb. d. spec. path. Anat.* II Berlin 188[illegible]

CHAPTER LXXXV.

PULMONARY INFLAMMATIONS IN GENERAL.

596. All **acute inflammations** of the lung of any intensity are marked by exudation into the respiratory air-spaces, the exudation following upon an initial congestive hyperaemia of the lung-tissue.

The exudation either consists of a clear albuminous liquid (as in inflammatory oedema), or contains a large number of leucocytes

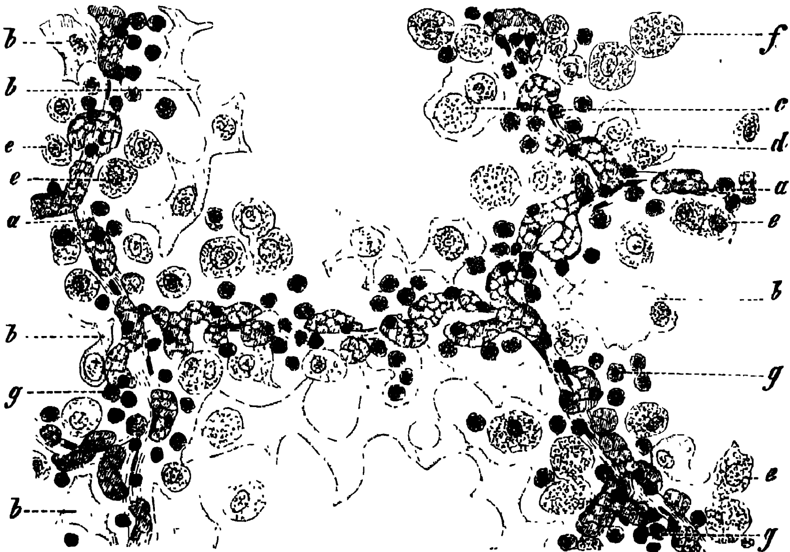


FIG. 224. RECENT BRONCHOPNEUMONIA.

(Section treated with Müller's fluid and picrocarmine, and mounted in glycerine: × 300)

- *a* alveolar septa with distended capillaries
- *b* detached epithelial plates, nucleated and non-nucleated
- *c d* epithelial plates containing granules and oil-globules around the nuclei
- *e* detached epithelial cells, nucleus little altered
- *f* swollen epithelial cells, nucleus obscured by granules
- *g* leucocytes

(as in catarrhal or purulent inflammation) or of red blood-cells (haemorrhagic exudation).

This exudation is always followed by more or less marked desquamation of the epithelium lining the alveoli, alveolar ducts, and respiratory bronchioles.

The large nucleated and non-nucleated epithelial plates (Fig. 224 *b*) are often detached unaltered; when the exudation is sudden and abundant they are often shed in coherent flakes. Oil-globules frequently occur in them (*c*), usually aggregated around the nucleus (*d*).

The small protoplasmic nucleated epithelial cells are also partially detached; many however remain all but unaltered (*e*), appearing only a little swollen or studded with fat-granules (*f*) which to some extent obscure the nucleus.

The blood-vessels are at first distended with blood (*a*), the alveolar septa and walls of the bronchi being saturated with liquid and beset with a moderate number of extravasated leucocytes. The lymphatics also contain some exuded liquid, and the lymphatic glands are swollen. When the onset of the inflammation is less sudden the exudation is at first more scanty, and the epithelial desquamation is accordingly less extensive.

The lung-tissue when recently inflamed is reddened, contains little air or none, and on pressure yields a more or less turbid grey or greyish-red or even blood-stained liquid.

The changes in the pulmonary epithelium and blood-vessels which accompany the beginning of inflammation have frequently been the subject of investigation histological and experimental. Experimenters have set up inflammation in the lung either by cutting the vagus nerve or the recurrent laryngeal nerve, or by injecting irritating liquids such as solution of perchloride of iron or solution (1 per cent.) of nitrate of silver. Section of these nerves causes paralysis of the laryngeal muscles, and saliva and other matters get into the air-passages from the mouth. When these are aspirated into the alveoli they set up a local inflammation, which is well-adapted for purposes of investigation.

References :—TRAUBE, *Gesamm. Abhandl.* I Berlin 1871 ; COLBERG, *Deut. Arch. f. klin. Med.* II 1866 ; FRIEDLANDER, *Untersuch. über Lungenentzündung* Berlin 1873, *Virch. Arch.* vol. 68 ; FREY, *Die path. Lungenveränderungen nach Lähmung d. N. vagi* Leipzig 1877 ; SOMMERBRODT, *Virch. Arch.* vol. 55 ; VERAGUTH, *ibid.* vol. 82 ; WAGNER, *Arch. d. Heilk.* VII, VIII ; CURSCHMANN, *Deut. Arch. f. klin. Med.* XXXII ; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884 ; FELD, *Experiment. Beiträge z. Schluck- und Vaguspneumonie* In. Diss. Bonn 1875 ; FEUERSTACK, *Ueber d. Verhalten d. Epithels d. Lungenalveolen bei d. fibrinösen Pneumonie* Gottingen 1882 ; HAMILTON, *Pathology of bronchitis* London 1883.

597. When the exudation has reached its highest point the affected tissue is usually devoid of air, the alveoli being filled with the exuded matters and with desquamated epithelium. We may distinguish certain varieties of pulmonary inflammation by the nature of the accompanying exudation.

In **haemorrhagic inflammation** the chief contents of the

alveoli are red blood-corpuscles, and the inflamed region has a dark-red or brown colour.

In **catarrhal inflammation** the contents of the alveoli consist mainly of liquid and small rounded cells with some admixture of larger squamous cells (Fig. 225). When these larger cells are the more numerous (Fig. 227 *c*) the affection is often spoken of as desquamative catarrh, the assumption being that the large cells are detached alveolar epithelial plates. This is however by no means always the case, for such cells are not infrequently developed from extravasated leucocytes. A portion of lung affected with catarrh looks red, greyish-red, grey, or greyish-yellow according as it contains much or little blood; on pressure it yields a greyish liquid more or less mingled with blood.

Croupous inflammation is characterised by the coagulation of the exudation, fine threads of fibrin appearing between the cells contained in the extravasated liquid (Fig. 226) and making the whole cohere into a compact semi-solid mass.

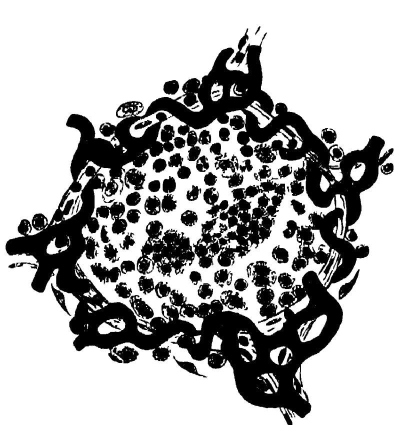


FIG. 225.

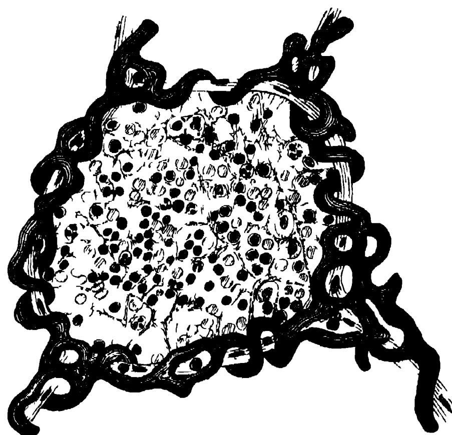


FIG. 226.

FIG. 225. CATARRHAL BRONCHOPNEUMONIA.

(*Injected preparation stained with haematoxylin*: ×80)

An alveolus filled with liquid and with large and small colourless cells

FIG. 226. CROUPOUS PNEUMONIA (RED HEPATISATION).

(*Injected preparation stained with haematoxylin*: ×80)

An alveolus filled with a coagulated exudation containing red and white corpuscles and epithelial cells

Coagulated exudations of this kind consist chiefly of liquid mingled with red and white blood-cells and epithelium, coagulation setting in as the white blood-cells dissolve.

Another form of coagulation is observed in exudations containing many large cells (Fig. 227) and tending to become caseous at a

later stage. In these the cells break up and dissolve entirely forming with the exuded liquid a granular and fibrinous mass (*d*)

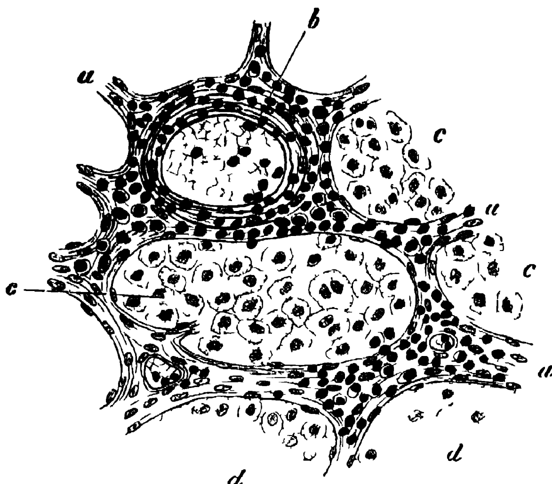


FIG. 227. CASEATING LOBULAR BRONCHOPNEUMONIA.

(*Section hardened in alcohol and stained with haematoxylin.* × 120)

a alveolar septa infiltrated with cells
b venule with infiltrated wall
c alveoli filled with large epithelioid cells
d alveolar contents consisting of granular and fibrinous coagula

when recent this contains a few nuclei, but soon these too disappear and the mass becomes uniformly fibrinous The two forms of coagulation are met with in combination

The coagulated exudation is more or less solid, and the affected parenchyma accordingly becomes firm and resistent, resembling liver in consistence: the condition is therefore described as **hepatisation** of the lung The surface on section is usually rough and granulated, the coagula projecting somewhat from the cut alveolar walls. The colour varies from deep-red (red hepatisation) to greyish-red or greyish-yellow (grey hepatisation), according to the amount of blood that is present and the composition of the exudation.

In many forms of pulmonary inflammation the changes within the contents of the alveoli are those that are most striking and important, the changes in the parenchyma itself being of secondary significance. These forms have been described as superficial in contradistinction to interstitial inflammations, in the latter marked changes (infiltration, hyperplasia, etc) are simultaneously set up in the connective tissues (Fig 227 *a b*) The distinction can frequently be made, but it is not exactly one of kind, as the two forms pass the one into the other through a number of transitional stages.

Cellular infiltration of the lung-tissue is never entirely absent in any pulmonary inflammation; but in some varieties it is slight and transient, in others intense and persisting. There is always in like manner a certain amount of exudation into the lymphatic vessels.

The extent of the inflammatory change varies greatly in different cases, and accordingly we have forms described as miliary, nodular, lobular, and lobar.

When the inflamed part of the lung is close to the pleural surface, the pleura in general becomes inflamed at the same time. Hyperaemia is first induced, and a more or less abundant exudation is then poured out on the free surface.

598. **Terminations of pulmonary inflammation.** The most favourable issue is in **resolution**, the exudation being removed and the altered tissue restored. The exudation may be removed by expectoration, but the greater part is re-absorbed.

In many forms of inflammation the pulmonary vessels continue permeable to injections throughout the entire course of the affection (Figs. 225, 226), and the lymphatics in like manner are not permanently obstructed by the inflammatory exudation. Resorption therefore goes on continuously, the exuded matters being carried off directly in a more or less altered condition. Coagulated and cellular exudations must of course become partially liquefied before they can be re-absorbed. This liquefaction is brought about by fatty and mucoid change and by disintegration and breaking up of the cells and fibrin, a turbid pulpy liquid containing granular detritus is thus formed.

While the exudation is in process of disintegration within the pulmonary tissue a certain amount of inflammatory action persists, manifested chiefly by the continued extravasation of leucocytes. The leucocytes play a part in the process of resorption by taking up into their protoplasm fragments of the unliquefied detritus and carrying these with them into the lymphatic channels. At the same time the loss of alveolar epithelium is made good by regenerative multiplication of the intact epithelial cells. When the new cells continue to be shed as they are produced we have the condition known as chronic desquamative catarrh.

A second but comparatively rare issue is in **suppuration**. It is characterised anatomically by an extremely abundant accumulation of leucocytes within the alveoli and in their walls, together with progressive disintegration and liquefaction of the latter. This destructive process is set up by the presence of some intensely irritant agent, giving rise to ferments which dissolve the pulmonary tissue.

A third issue, also not very common, is in **gangrene**. The conditions for its appearance are—first, extreme disturbance and in parts suppression of the circulation, and secondly, the presence in the affected part of putrefactive micro-organisms. The

gangrenous tissue is transformed into a dark-brown dirty mass, changing presently into a greenish-black foul-smelling sanious *pulp* or pus: this at first contains shreds and fragments of pulmonary tissue, but these too at length dissolve and disappear. The gangrenous pus contains various chemical products of disintegration of albumen and fat, such as leucin, tyrosin, margarin, volatile fatty acids, especially butyric, sulphuretted hydrogen, ammonia, etc. The more solid contents include granular detritus, pus-corpuscles, pigment, shreds of lung-tissue, oil-globules, margarin-needles, crystals of triple-phosphate, and various micro-organisms. The latter are the prime cause of the chemical decomposition and of the disintegration of the pulmonary tissue. According to FILEHNE a certain ferment is formed by them which acts like trypsin, and in alkaline solutions quickly dissolves elastic tissue.

Caseation most frequently occurs as a sequel of tuberculous inflammation, though it is also not entirely absent in other forms. It would thus appear to depend on some peculiar property of the exciting cause of the inflammation, though under special conditions it may occur in connexion with inflammations which usually terminate in a more favourable way. So far as mere morbid anatomy is concerned we may say that caseation takes place most frequently in inflammations which are characterised by dense cellular infiltration of the parenchyma of the lung and accompanied by extensive alteration of the walls of the lymphatics and blood-vessels. The latter feature is most marked in tuberculous inflammation, and thus the anatomical and the aetiological characters are in this regard largely co-extensive.

In caseous degeneration the exudation within the alveoli necroses, and is in the first instance transformed into a fibrinous and granular mass (Fig. 227). In other cases it appears homogeneous, or the extravasated cells lose their nuclei and break down into fatty granular detritus. As a rule the alveolar walls also become speedily necrotic and caseous. The vessels are blocked up, the nuclei of the tissue-cells disappear, the contours of the tissue-fibres become indistinct, and at length the pulmonary tissue becomes granular or homogeneous and structureless, almost or altogether indistinguishable from the caseous exudation proper. When the walls of the larger vessels have been much infiltrated they too become caseous in like manner.

The last and not uncommon termination of a pulmonary inflammation is in the formation of new fibrous tissue and **cirrhosis**.

New fibrous tissue is developed when the cellular infiltration of the parenchyma of the lung is long-continued, the circulation at the same time remaining ample for the nutrition of the part. In such conditions large formative or fibroblastic cells make their appearance first in the alveolar walls (Fig. 228 *a*) and in the circumvascular, peribronchial, and interlobular connective tissue,

and at length in the pleura also. These cells develope into fibrous tissue in the usual way (Art. 108), and so give rise to thickening of the affected parts and consequently to diminution of the respiratory spaces. As collapse very commonly accompanies this fibroid change the thickened alveolar walls speedily come into contact and cohere, and the corresponding alveolar cavities are obliterated. Some of the alveoli however may remain open, and these become lined with short cylindrical epithelial cells, so that on section they somewhat resemble the acini of a gland.

Not infrequently the fibrous hyperplasia in the alveolar walls is accompanied by a like development within the alveoli: large epithelioid formative cells (Fig. 228 *d*) make their appearance in the alveolar contents, and growing out as bands or strings of cells (*e*) or as bud-like processes from the alveolar wall traverse the exudation in various directions At the same time buds and outgrowths spring from the capillaries of the alveolar wall (*g*); these push their way into the new tissue and being transformed into blood-vessels provide for its nutrition The whole process corresponds closely with that by which a thrombus is organised (Art. 255).

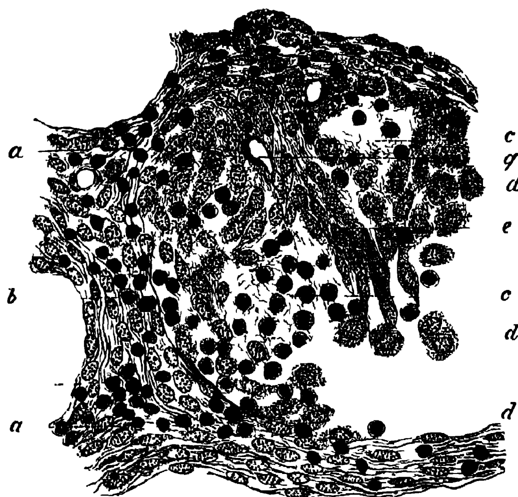


FIG. 228. GROWTH OF FIBROUS TISSUE IN THE WALLS AND IN THE CONTENTS OF AN ALVEOLUS.

(*Haematoxylin staining* ×150)

a alveolar wall thickened and fibroid
b small leucocytes
c fibrinous and cellular exudation
d intra alveolar formative cells
e string of fusiform fibroblasts
g new-formed blood-vessel

Pulmonary tissue thus thickened by fibroid induration is firm and tough and usually devoid of air. Its colour varies from white to slaty-grey or even black, according to the amount of pigment present.

Caseation and fibroid induration are very frequently met with in combination, the caseous foci being surrounded and enclosed by new and cellular fibrous tissue.

599. **Causes of pulmonary inflammation.** The inflammations of the lung are set up by irritants reaching it by way of the blood-vessels or of the bronchi, or by extension from the pleura or mediastinum. We may therefore conveniently consider these inflammations according to their various modes of origin.

As regards the pulmonary inflammations whose exciting cause is referable to the blood it must be observed that the lung is not on the whole so liable as other organs to be the seat of contaminating deposit from the blood. Thus pigment-granules and micro-organisms may circulate freely through the capillaries of the lung without being arrested; this is doubtless due to the fact that the capillaries are comparatively wide and the blood-stream rapid. Deposits from the blood do however occur, and thus we meet with forms of haematogenous infiltration and haematogenous (bacterial) infection.

When the blood contains an excessive proportion of white corpuscles, these may accumulate in great numbers in the capillaries of the lung, and by extravasation in the tissues also, and give rise to **leukaemic infiltration.** Fat and oil-globules circulating in the blood (as in lipaemia) are apt to collect in the pulmonary vessels causing fatty embolism; and in anthrax the specific bacilli frequently crowd the capillaries so as to look like an artificial injection of them.

Four kinds of haematogenous infective inflammation are described; they may be described as **pneumonias** in a restricted sense of the term. They are—true croupous pneumonia, embolic septic (suppurative or gangrenous) pneumonia, embolic tuberculosis, and embolic syphilis. They are probably all due to bacterial infection, and we must assume that the bacteria are conveyed by the blood.

What we may term the **pleurogenous pneumonias** are closely allied to those just referred to. The inflammatory process extends from the pleura to the lung-tissue chiefly along the interlobular lymphatic channels, though here and there it passes thence directly to the peribronchial tissue and to the pulmonary parenchyma. The antecedent pleuritic affection is generally itself haematogenous. Traumatic pneumonia may be considered as a special pleurogenous variety, pleura and lung being generally injured simultaneously.

An inflammation of the lung induced by an irritant conveyed to the parenchyma by the bronchi is described as a **broncho-pneumonia.** It is immaterial whether the bronchi themselves are previously or simultaneously inflamed or not.

600. **Inhaled impurities.** The lungs are by reason of their

function exposed to the access of numerous impurities. We all inhale a certain amount of dust with the air of the street or of the house, while in certain occupations the amount of dust necessarily inhaled is very considerable. Workers in stone of all kinds, masons, bricklayers, potters, inhale mineral and earthy dust; workers in metal such as grinders, gilders, braziers, typefounders, and so on, inhale metallic particles; millers, colliers, coal-heavers, chimney-sweeps, bakers, cabinet-makers, rope-makers, cigar-makers, and workers in spinning and weaving mills, live in an atmosphere charged with dust of vegetable origin. Brush-makers, upholsterers, barbers, cloth-dressers, and hat-makers breathe air containing animal dust; and glass-workers, street-sweepers, etc. dust of various other kinds.

A large proportion of the dust thus inhaled is caught in the air-passages, but some of it especially in deep inspiration is carried into the parenchyma of the lung. Many of the particles adhere to the walls of the alveoli; others are promptly conveyed into the lymphatic channels communicating with the alveoli, and thence are carried by the peribronchial and interlobular lymphatics into the lymphatic glands at the root of the lung.

When a considerable number of dust-particles reach the parenchyma of the lung they set up a slight inflammation manifested by emigration of white blood-cells from the vessels and the desquamation of some of the alveolar epithelial cells.

The extravasated cells take up the foreign particles, sometimes in such abundance that they have been fitly termed **dust-cells** (LANGHANS, VON INS). They may be carried into the bronchioles and bronchi and are then ejected with the sputa. Much the larger number of them are however carried into the lymphatics.

Within the lymphatics certain kinds of dust, such as chalk-particles, are dissolved. Insoluble dusts are either carried into the bronchial glands or are deposited in the walls of the lymphatic vessels. This deposit takes place wherever lymphatics occur, that is in the interalveolar, interlobular, subpleural, pleural, circumvascular, and peribronchial fibrous tissues, especially in those parts where aggregations of lymphoid elements are normally met with. The particles lie either free in the tissues or enclosed in rounded, fusiform, or stellate cells.

Coloured dust gives rise to pigmentation of the lung, while the larger grains appear as sandy or gritty deposits. Some forms of dust-deposit, in particular those which give rise to marked change in the lung, have received special names. The most frequent as well as the best-known form is that due to the inhalation of soot or coal-dust, by which the lung becomes dark-grey or black; it is variously described as **anthracosis** or *pneumonoconiosis anthracotica* (*κονις* dust, *ανθραξ* coal), and the lung as collier's or **miner's lung**. This form of pigmentation is very common, and is seldom entirely absent in adult lungs. It must however be remembered that all

black pigmentations of the lung are not anthracotic, for black pigment is frequently a derivative of the colouring-matter of the blood (Arts. 68, 268). A second form is the so-called **siderosis** (compare Art. 268) or *pneumonoconiosis siderotica* (σιδηρος iron) of ZENKER, due to the inhalation of metallic dust; in the lung it appears as oxide or sesquioxide or phosphate of iron. Oxide of iron (rouge) is used as a pigment and as a polishing-material; it gives rise to a brick-red pigmentation of the lung, the other iron-compounds tending rather to blacken it. The deposit of stone-dust, especially of quartz, flint, and glass, has been called **chalicosis** (χαλιξ grit); dust from clay as inhaled by porcelain-workers and makers of artificial ultramarine gives rise to **aluminosis**. Grinders inhale mixtures of steel-dust and grit which cause the affection known as **grinder's asthma** or grinder's rot.

PEARSON, THOMSON, ROBIN and others surmised that part at least of the black pigmentation so frequently found in the lung was derived from inhaled soot and coal-dust: TRAUBE verified this by actually demonstrating the presence of microscopic particles of coal in the lung and sputum. COHNHEIM thinks that the black pigment of the lung is entirely of this nature; but VIRCHOW is no doubt right in referring some of it to altered blood-pigment. ZIEGLER has found that in a very large number of cases the lung-tissue and the bronchial glands contain broken-down red corpuscles, corpuscle-carrying cells, yellow and brown flakes, and granules of pigment. This is especially the case in parts that have been altered in any way by inflammation.

ZENKER'S researches were the first to give us precise information on siderosis.

KUSSMAUL, SCHMIDT, and MEINEL have examined the mineral residue (ash) of lung-tissue, and have shown that in chalicosis the amount of silica present is remarkably increased. LEWIN, VILLARET, CROCQ, VON INS, RUPPERT, SCHOTTELIUS, and others have experimented on dust-inhalation.

References:—PEARSON, *Phil. Trans.* 1813; THOMSON, *Med. chir. Trans.* XX, XXI (1837); ROBIN, *Traité de chimie anatomique* III (1853); TRAUBE, *Deutsche Klinik* 1860; ZENKER, *Deut. Arch. f. klin. Med.* XIII; KUSSMAUL, *ibid.* II; GREENHOW, *Lancet* 1, 1869, *Trans. Path. Soc.* XVI *et seq.*, *Report of Med. Off. to Privy Council* 1861; MEINEL, *Deut. Viertelj. f. offentl. Gesundh.* 1876; VIRCHOW, *Virch. Arch.* vols. 1, 35, *Edin. Med. Journ* 1858; LEWIN, *Beiträge z. Inhalationstherapie* Berlin 1863; VILLARET and CROCQ, *Schmidt's Jahrb.* 116, 126; VON INS, *Arch. f. exp. Path.* V; KNAUFF, *Virch. Arch.* vol. 39; SLAVJANSKY, *ibid.* vol. 48; RUPPERT, *ibid.* vol. 72; SOYKA, *Prag. med. Woch.* 1878; MERKEL, *Ziemssen's Cyclop.* I; HIRT, *Staubinhalationskrankheiten* Breslau 1871; SMITH, *Med. Times* 1, 1881; HESSE, *Viertelj. f. gerichtl. Med.* XXXVI (1882); SELIGSOHN, *Eulenburg's Realencyclopädie* Article *Staubkrankheiten;* WEICHSELBAUM, *Cent. f. med. Wiss.* 1882, *Wiener med. Jahrb.* 1883; BUHL, *Naturforscherversammlung in Munchen* 1877; HARRIS, *Journ. of Anat. and Physiol.* XV 1881; ARNOLD, *Staubinhalation* Leipzig 1885.

601. The kinds of dust described in the last article, when in small quantities, give rise to no serious change in the lung, other than pigmentation. This is especially true of coal-dust of which very considerable quantities may be inhaled without injury. Metal-dust and grit are more dangerous, for in any but small amounts they set up inflammations which in some cases are not slight or transient but give rise to very marked alteration in the lungs. Dust-inhalation is thus the exciting cause of a group

of bronchopneumonic affections ending in chronic pulmonary change.

If insoluble dust is capable of acting in this way, much more will dust containing soluble chemically-active substances, and organised or microparasitic irritants.

The air we breathe, especially in thickly-populated places, very frequently contains such matters, and some of them must reach the lung and be deposited on the alveolar walls or enter its tissue or the lymphatics. Many of them do no noticeable harm, others and especially the micro-organisms pass from the lung into other parts of the body, and act as the specific causes of infective disease. Others again give rise to local inflammatory change in the lung itself at the places where they settle. The bacillus of tuberculosis (or its spores) is probably the most striking example, and there is no doubt that other disease-producing agents reach and act on the lung in a similar way.

In addition to these irritants inhaled with the air from the atmosphere without, we may have disease set up by inhalation of matters derived from the body itself, and carried into the alveoli of the lung from the mouth, nose, pharynx, larynx, or air-tubes. Saliva and particles of food may be aspirated instead of swallowed, and pus from the larynx or bronchi may be carried into the respiratory parenchyma instead of being coughed up. The former occurs in very young or comatose patients, and the latter in those suffering from laryngitis or bronchitis.

These substances when thus aspirated usually set up more or less intense inflammation, especially when they are putrescent or contain putrefactive organisms, or specifically virulent agents such as the bacilli of tuberculosis or of glanders.

Very various forms of bronchopneumonia, specific and non-specific, are thus induced, their course and character depending on the nature of the exciting cause. Tubercle-bacilli give rise to inflammatory processes tending to caseation; the products of catarrhal bronchitis as a rule set up a similar catarrhal broncho-pneumonia, slight and usually transient in character; pus from a perichondritic laryngeal abscess tends to cause violent suppurative inflammation of the lung, and putrescent particles of food may lead to gangrene.

Many experiments have been made on the action of saliva, decomposing organic substances, and bacteria, when aspirated into the lung. The numerous experiments on so-called **vagus-pneumonia** are of this nature. This form of inflammation is observed when the vagus and recurrent laryngeal nerve are cut, and is due to the fact that the paralysed larynx permits saliva and foreign matters from the mouth to be drawn into the lung. Other investigators have conveyed into the bronchi liquids or pulverulent matters (dry or suspended in water), others again have caused animals to breathe various substances suspended in the air by means of spray. LIPPL, TAPPEINER, SCHWENINGER, SCHOTTELIUS, WEICHSELBAUM, VERAGUTH, and others have in this way tested the infectiveness of phthisical sputum.

The result of such inhalation-experiments depends on the nature of the

matters inhaled and on the mode of experimentation. When finely-divided irritant substances, such as spray of phthisical sputum or of putrid liquids, are inhaled, small miliary bronchopneumonic foci are produced. When the inhaled matters are coarser or of larger volume, and of an irritant nature, we have large usually lobular patches of inflammation with haemorrhage, suppuration, or gangrene, as the case may be. When the foreign matters are bulky enough to occlude one or more of the bronchioles the first effect is partial collapse or atelectasis. Large quantities of liquid quickly introduced into the lung may lead, as in drowning, to death by asphyxia. The liquid is carried with the inspired air into the alveoli, and fills them with a mass of froth.

References :—Art. 596; TRAUBE, *Beitrage z. Path. u. Phys.* I Berlin 1871; BODDAERT, *Lésions pulmon. conséc. à la section d. nerfs pneumogastriques* Brussels 1862; FRIEDLANDER, *Untersuch. ub. Lungenentzundung* Berlin 1873, *Virch. Arch.* vol. 68; FREY, *Die path. Lungenveranderungen nach Lahmung d. Nervi vagi* Leipzig 1877; SCHOTTELIUS, *Virch. Arch.* vol. 73; BUHL, TAPPEINER, LIPPL, SCHWENINGER, *Naturforscherversammlung in Munchen* 1877; TAPPEINER, *Virch. Arch.* vols. 73, 82; HEIDENHAIN, *ibid.* vol. 70 (inhalation of hot steam).

CHAPTER LXXXVI.

FORMS OF PNEUMONIA.

602. **Croupous pneumonia** is an inflammation of one or more lobes of the lung, and is the characteristic symptom of a certain specific infective disease. The disease is acute, and the anatomical change which accompanies it is the appearance of a firm or solid exudation within the pulmonary alveoli.

The exudation may be limited to a portion of one lobe or appear in several isolated patches; but more usually it extends over the greater part or the whole of one lobe, or over the entire lung. Occasionally indeed both lungs are affected. The exudation either reaches its full extent suddenly and rapidly, or advances by successive stages.

The process begins with intense congestive hyperaemia, by reason of which the lung appears of a deep red colour. This is the stage of **congestion** (*engouement*). The hyperaemia is accompanied by exudation from the vessels, by which in a short time the air is driven out of the alveoli, alveolar ducts, and respiratory bronchioles. At the same time the protoplasmic epithelial cells, and the homogeneous plates lining these spaces, are at least in part detached or shed (Fig. 224, Art. 596).

The alveolar contents thus consist (Fig. 226, Art. 597) of albuminous liquid, red and white blood-cells, and desquamated pulmonary epithelium. After a time coagulation takes place, granules and filaments appearing between and uniting the cellular elements into a solid mass adhering to the internal surface of the alveolus.

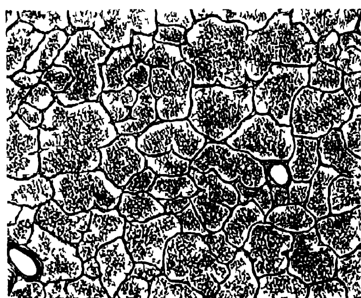


FIG. 229. CROUPOUS HEPATISATION OF THE LUNG.

(*Hardened in Müller's fluid and stained with alum-carmine:* × 20)

The coagulation of the exudation marks the beginning of the

stage of **red hepatisation** (Fig. 229). The lung is bulky, heavy, firm, and airless. The cut surface is red or greyish-red and granulated, the plugs which distend the alveoli protruding somewhat beyond their walls. The pleura over the affected region is turbid and covered with a thin film of fibrin: the costal surface is often marked by shallow impressions of the ribs. In the neighbourhood of the infiltrated region the lung-tissue is frequently oedematous or filled with a turbid greyish exudation containing numerous leucocytes.

During the stage of red hepatisation the lung is still highly vascular and filled with blood, the red tint being due not only to the extravasated red corpuscles but also to the blood which distends the capillaries. When the red corpuscles are extravasated in very large numbers the exudation assumes a dark-red tint like that of haemorrhagic infiltration.

The stage of red hepatisation passes gradually into that of **grey hepatisation.** The change of tint is mainly due to the decolorisation of the exudation and the accompanying anaemia of the lung-tissue. It must be remembered that in ordinary cases the pulmonary vessels remain throughout permeable by injections, while the normal structure of the lung continues quite distinct (Fig. 229). As the exudation loses colour the cells it contains break down by fatty change and disintegration into granules and flakes, and they with the fibrin begin to dissolve. Leucocytes now migrate freely from the vessels, some of which remain clinging to the vessel-walls while others mingle with the liquefying exudation.

These changes result in the **colliquation** of the firm coagula, and when the lung is cut and scraped an abundant turbid whitish or greyish juice comes away, and the plugs that still fill the alveoli are loose and easily removed. The **resolution** of the pneumonia has set in.

The bronchi of the affected part are throughout the changes just described the seat of inflammatory change, and contain a mucous or sero-mucous secretion stained brown or red ('prune-juice' or 'rusty' sputum) with blood-pigment. In the later stages the secretion is mingled with liquefied exudation from the bronchioles and alveolar ducts. Sometimes croupous casts of the smaller bronchi are formed.

We alluded in Art. 204 to the fact that KLEBS, KOCH, and FRIEDLÄNDER had observed the presence of micrococci in true croupous pneumonia. More recent investigations by FRIEDLANDER, FROBENIUS, and others make it not improbable that these micro-organisms (round or oval diplococci surrounded by a gelatinous capsule) are in causal relation to the disease. If this be established the view long maintained by JURGENSEN—that croupous pneumonia is the symptom of a specific infective disease—will be confirmed. The clinical course, the definite duration of the accompanying fever, and the occasional epidemic character of the disease—all point in this direction.

In addition to this idiopathic form croupous pneumonias sometimes appear in the course of various infective diseases such as malarial fever, erysipelas, and typhoid, and in acute rheumatism. According to E. WAGNER these forms

have probably no aetiological connexion with the first, but are due to the action of the specific poisons of the respective primary affections.

References :—Art. 204 ; EBERTH, *Deut. Arch. f. klin. Med.* XXVIII ; FRIEDLÄNDER, *Fortschritte d. Med.* 1883, *Virch. Arch.* vol. 87 ; JURGENSEN, *Ziemssen's Cyclop.* V, and *Die croupöse Pneumonie* Tübingen 1884; E. WAGNER, *Deut. Arch. f. klin. Med.* XXXIII ; SALVIOLI and ZASLEIN, *Cent. f. med. Wiss.* 1883 ; HEITSCH, *Ueb. infect. Pneumonie* In. Diss. Leipzig 1883; MENDELSOHN, *Die infect. Natur d. Pneumonie, Zeitschr. f. klin. Med.* VII ; ZIEHL, *Cent. f. med. Wiss.* 1883 ; GÜNTHER, *Zeitschr. f. klin. Med.* 1883 (micrococci in living patient); Discussion, *Congress f. innere Med.* Wiesbaden 1884; *Collective Investigation Record* II London 1884; DRESCHFELD, *Brit. Med. Journ.* 1, 1884, *Fortschritte d. Med.* III 1885; KLEIN, *Micro-organisms and Disease* London 1884 ; EMMERICH, *Fortschritte d. Med.* 1884; PURJESZ, *D. Arch. f. klin. Med.* XXXV ; SENGER, *Arch. f. exp. Path.* XX ; CORNIL and BABES, *Les bactéries* Paris 1885 ; STERNBERG, *Amer. Journ med. sci.* 1885 ; Discussion, *Brit. Med. Journ.* 2, 1886.

The composition of the exudation varies much in different cases. We have already remarked that the number of extravasated red corpuscles is by no means constant; the white cells and the amount of fibrin formed is also variable. In the pneumonia of aged patients the fibrin is often scanty, so that the exudation has rather the character of inflammatory oedema, and only in isolated spots is firmly solidified. The like happens now and then in younger persons, and is indicated by the rapidity with which the affected regions recover and again contain air. It appears also that in certain cases the process may stop short at the stage of congestion, the commencing exudation being rapidly re-absorbed. The time at which hepatisation is complete is also to some extent variable, so that no definite statement can be made as to the precise duration of each stage. All we can say is that during the first two days the hepatised lung is red in tint, after that it becomes pale. Sometimes the transition takes place irregularly, the lung showing patches of greyish-red, greyish-white, and yellow simultaneously.

603. As the coagulated exudation liquefies its removal becomes possible. This takes place chiefly by re-absorption, in part also by expectoration. During this process the lung appears as if saturated with moisture; it is beset with leucocytes but not in excessive number, and its tissue is easily torn.

In the great majority of cases complete recovery takes place, so that after re-absorption is complete nothing remains of the affection. The time required to bring this about varies much in different cases. Not infrequently there is for weeks some dulness to percussion over the affected region.

In few cases does any permanent textural change remain, but it is possible for the pneumonic exudation to issue in gangrene, suppuration, or cirrhosis of the lung.

Gangrene of the lung occurs when the pulmonary vessels are so gravely injured that the circulation comes to a stand-still, while putrefactive organisms gain access to the affected parts. The former condition is most frequently met with in drunkards and ill-nourished persons, in whom the pneumonic exudation often has a haemorrhagic character. The latter condition is most likely to arise in cases where before the attack of pneumonia bronchiectases or other cavities containing decomposing secretion exist in the lung.

The destruction of the lung may take place in isolated patches

or continuously. The tissue is transformed into a tindery or pulpy mass with a characteristic intensely foetid odour. When a gangrenous patch lies immediately beneath the pleura the latter may be raised up in bullae or blisters, or the softened mass may break through into the pleural cavity.

The tissue surrounding the gangrenous part is inflamed and infiltrated, often haemorrhagic. Death usually ensues either from intense pleurisy or from putrid poisoning. If recovery takes place, the gangrenous portion is separated off from the healthy by a zone of granulations, and gradually removed: in most cases a cavity remains which may be the starting-point for fresh inflammatory mischief.

Another and comparatively uncommon issue is in **suppuration**, due to excessive extravasation of leucocytes in the later stages of the pneumonia. Sometimes patches of necrosis are the starting-point of the suppuration. The accumulation of leucocytes appears partly in the alveoli, partly in the substance of the lung-tissue, and may be disseminated or diffuse. The tissue becomes yellow and very brittle; here and there it may break up and dissolve outright. Large abscesses are however very rare indeed, and are probably formed only where some previous morbid alteration has already existed.

The pus thus formed may find an exit in various directions. Most frequently it is evacuated through the bronchi. Death is a common termination; though the suppurative process may come to an end and granulations spring up, by which cicatrisation is effected, or a cavity bounded by new-formed connective tissue remains.

The frequency of gangrene, suppuration, and caseation as terminations of pneumonia is still matter of discussion. LEYDEN doubts whether a lung previously healthy ever becomes gangrenous or suppurates after pneumonia. It is however by no means always possible to demonstrate *post mortem* the presence of previous morbid change. It is to be doubted whether croupous pneumonia ever issues in caseation.

References:—JURGENSEN, *loc. cit*; LEYDEN, *Sammlung klin. Vortrage* 114, 115, *Deut. Zeitschr. f klin. Med.* II; BUHL, *Lungenentzundung Tuberculose und Schwindsucht* 1872, *Arbeiten a. d. path. Inst. zu Munchen* 1878; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* III.

604. Another termination of croupous pneumonia, not very common it is true but by no means rare, is in collapse and induration of the lung, a condition which is best described as **simple cirrhosis**.

In some cases this comes about by the lung failing to expand after the resolution and absorption of the exudation. This may be due to persistent obstruction of the bronchi (Art. 592, Fig. 221) or to compression from without. The walls of the unexpanded alveoli soon become coherent and undergo a certain amount of thickening.

In other cases the absorption of the exudation is incomplete: weeks and months elapse and the consolidation does not disappear. The inflammatory condition is maintained, repeated extravasations

of cells from the blood-vessels into the alveoli take place, and the lung-tissue itself is the seat of inflammatory infiltration. In process of time new fibrous tissue is formed both within the alveoli and in the interalveolar septa (Art. 598, Fig. 228). In this way more or less extensive fibroid induration of the lung takes place: in many places it is transformed into a dense airless mass of fibrous tissue, usually containing pigment (Fig. 230); in other parts the alveolar walls are thickened (*b*) or infiltrated with cells, or the alveoli are filled with leucocytes or new-formed cellular tissue (*c*).

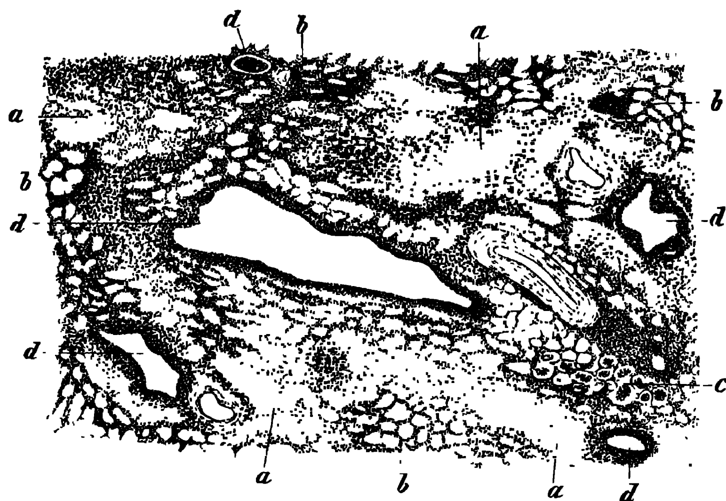


FIG. 230. SIMPLE CIRRHOSIS OF THE LUNG.

(*Hardened in alcohol and stained with carmine* : × 15)

dense pigmented fibrous tissue
alveoli with thickened and infiltrated septa
c alveoli filled with cells
dilated bronchi with infiltrated walls

The cirrhotic patches have in the earlier stages a grey or greyish-red or greyish-yellow tint, and a small quantity of turbid exudation can here and there be squeezed from them. But where the development of fibrous tissue in the alveoli or their walls has begun, the lung is dense, firm, airless, and fleshy, having something of the appearance of freshly hepatised lung. The condition is well described as **carnification**. When the fibroid transformation is complete the tissue is firm and continuous, and white or slaty-grey in colour.

The extent of the induration left by an antecedent pneumonia varies very greatly. It may be limited to the stratum immediately beneath the pleura, or extend over the greater part of a lobe. It may be continuous, that is uninterrupted by islands of air-containing tissue, or it may take the form of fibrous bands traversing the parenchyma in various directions and not very sharply marked off

from it. This variety of cirrhosis is indeed always characterised by the peculiarity—that it occurs not in well-defined nodes or groups of nodes, but in bands and patches which pass gradually into the air-containing tissue. This character is obscured only when secondary bronchopneumonic or peribronchial inflammation sets in.

The pleura overlying the cirrhotic patches is usually thickened and adherent to the costal pleura. The patches are usually shrunken and contracted, and the intervening alveoli emphysematous. After a time, if the induration and contraction are at all extensive, the corresponding bronchi are distorted and more or less dilated (Fig. 230 *d*); sometimes they are also ulcerated. For months and it may be years a chronic inflammation of the bronchi and of the pulmonary parenchyma is kept up, its existence being indicated by the patches of cellular infiltration that lie scattered throughout the affected region.

The occurrence of indurative contraction of the lung as a sequel of croupous pneumonia is regarded by most authorities as indisputable. BUHL however maintains that the form of pneumonia which leads to contraction is *ab initio* distinct. According to him it begins with cellular infiltration of the parenchyma of the lung, and the filling of the alveoli with desquamated epithelium, and issues in cirrhosis and caseation. He names it 'desquamative pneumonia' and considers it as a local manifestation of a general disease. This desquamative pneumonia is not however a pathological entity: BUHL'S cases were partly cases of croupous pneumonia, partly of tuberculous, lobular, and confluent bronchopneumonia (Arts. 606, 617).

Within the last ten or twelve years ZIEGLER has had the opportunity of examining a large number of cases of post-pneumonic cirrhosis in various stages of development, and the account in the text is drawn up from actual observation. MARCHAND'S account agrees in the main with the above, though he has laid somewhat exclusive stress on the intra-alveolar formation of fibrous tissue.

References:—LAENNEC, *Traité de l'auscultation médiate* Paris 1819; ROKITANSKY, *Path. Anat.* III; FORSTER, *Path. Anat.*; HESCHL, *Prag. Vierteljahresschr.* vol. 51; EPPINGER, *ibid.* vol. 125; MARCHAND, *Virch. Arch.* vol. 82; BIERMER, *Virchow's Handb. d. spec. Path.* V; BUHL, *loc. cit.*; JURGENSEN, *Die croupose Pneumonie* Tubingen 1883; THOMAS, *Gerhardt's Handb. d. Kinderkrankh.* III; LÉPINE, *Nouveau Dictionnaire* XXVIII Paris 1880; LEYDEN, *Berl. klin. Woch.* 1879; E. WAGNER, *Deut. Arch. f. klin. Med.* XXXIII; NOTHNAGEL, *Sammlung klin. Vortrage* 66; AMBURGER, *Deut. Arch. f. klin. Med.* XXXIII; BASTIAN, *Reynolds' Syst. of med.* II London 1876; STURGES, *Pneumonia* London 1876; COUPLAND, *Trans. Path. Soc.* XXX 1879; HEITLER, *Wien. med. Woch.* 1884.

605. **Embolic septic pneumonia** always occurs in isolated patches, whose appearance varies in different cases. When infective matters enter the circulation from a septic wound, some may be arrested in the lung and give rise to embolic infarction. Suppurative inflammation is set up around the infarcted tissue, by means of which the latter is surrounded by a zone of yellowish infiltration, and presently is loosened and separated from the healthier tissue. It then naturally undergoes necrosis and breaks up under the action of continued suppuration, so that at length there is formed a cavity filled with pus, a **metastatic abscess** of the lung. If the

septic embolus contain putrefactive organisms, or if these enter the infarct from the bronchi, the tissue may undergo putrid change or gangrene, and so be transformed into a foul dirty-grey or blackish mass.

When the original irritant reaches the vessels of the lung in the form of fine particles, such as micrococci, which are not arrested till they reach the capillaries and there lodge, the patches of inflammation are usually small and ill-defined. At first the inflammation is as a rule haemorrhagic in character, but no infarct is formed and the patches speedily become purulent or gangrenous.

In recent cases the tissue appears saturated with blood-corpuscles and pus, the pulmonary epithelium desquamated and partially necrosed. In the gangrenous patches the lung-tissue is disintegrated and dissolved (Art. 598).

When the septic embolism is subpleural, the pleura is always simultaneously inflamed. The exudation is purulent or fibrino-purulent, and may extend over the entire surface of the membrane.

Within the lung the suppuration and gangrene may extend by continuity to the neighbouring tissue. The inflammation set up is usually haemorrhagic and fibrinous in character, and speedily passes into suppuration and gangrene. Sooner or later the process reaches the peribronchial and interlobular lymphatics, and they become filled with serous, fibrinous, and purulent exudations, while the tissue about them becomes infiltrated with cells. This lymphangitis and perilymphangitis may start either from an embolic abscess or from a purulent pleurisy. In the latter case the interlobular tissues are the most affected.

The embolic abscesses may break through either into bronchi or into the pleural cavity, the former being the commoner event. When adhesions unite the lung to the thoracic wall or to the diaphragm, the pus may find its way to the exterior or into the abdomen.

The smaller abscesses may heal up more or less perfectly by absorption of the pus, the larger by rupture and evacuation; granulations are formed round the cavity, and develope into cicatricial tissue. If the absorption of the pus is incomplete it may become inspissated and calcified. Adhesions are invariably the result of the healing of the pleuritic patches.

JÜRGENSEN and SCHUPPEL have raised the question whether the cattle-disease called **pleuro-pneumonia** does not also occur in man (WIEDERMANN, *Deut. Arch. f. klin. Med.* XXV; SUSSDORF, *Die Lungenseuche d Rindes* In. Diss. Tübingen 1879; BRUYLANTS and VERRIERS, *Bull. de l'acad. belgique* 1880; PÜTZ, *Seuche- und Herdekrankheiten* Stuttgart 1882; POELS and NOLEN, *Cent. f. med. Wiss.* 1884; KORÁNYI and BABES, *Pest. med. chir. Presse* 1884; CORNIL and BABES, *Les bactéries* Paris 1885). This is an infective disease of bovine cattle, the main symptom being an affection of the lung characterised by red hepatisation with extensive interlobular and pleural inflammation. The lobules appearing red and the swollen and infiltrated interlobular septa

yellow, the surface has a typically marbled appearance. The exciting virus is probably a micrococcus.

The septic (suppurative and gangrenous) inflammations of the lung which occur in new-born infants are in general bronchopneumonias due to aspiration of decomposing genital secretions or liquor amnii; sometimes they are due to embolic infection from the unhealed stump of the umbilical cord. The pleura and interlobular septa are usually much inflamed at the same time.

References:—P. MÜLLER, *Gerhardt's Handbuch d. Kinderkr.* II; ORTH, *Arch. d. Heilk.* XIII; RUNGE, *Zeitschr. f. Geburtshülfe*, VI (1881); SILBERMANN, *Deut. Arch. f. klin. Med.* XXXIV, and *Die septische Pneumonie d. Neugeborenen* In. Diss. Breslau 1883.

606. **Embolic tuberculosis** of the lung occurs in two forms. The commonest and best-known is miliary tuberculosis, the rarer is the embolic localised form.

Miliary tuberculosis of the lung is set up when tubercle-bacilli enter the circulation in considerable numbers, and lodge in the pulmonary capillaries. As they settle and multiply they give rise to the formation of miliary nodules or tubercles, which are numerous or scanty according to the number of bacilli introduced. Usually they are distributed pretty uniformly through the parenchyma of the lung and the pleura, though sometimes they are concentrated more closely in one part.

The formation of the tubercles begins with a localised cellular infiltration in the alveolar septa (Fig. 231) or other element of the pulmonary tissue where the bacilli have found a nidus.

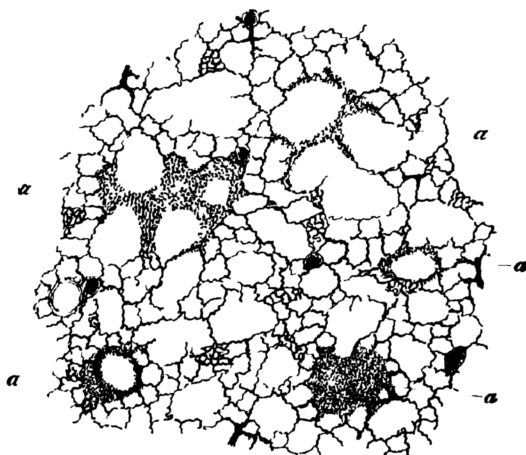


FIG. 231. MILIARY TUBERCULOSIS OF THE LUNG.
(*Preparation injected, and stained with carmine.* × 30)
a a tubercles

The recent tubercles have all sorts of irregular shapes—crescentic, annular, stellate, and so on. Later on an accumulation of cells takes place in the neighbouring alveoli and ducts and the

nodules become more rounded, though even in this stage they frequently have processes and projections corresponding to the thickened alveolar septa. Where a tubercle forms the capillary-system of the part is always destroyed, so that a fully-developed tubercle is non-vascular.

Recent (or 'crude') tubercles are grey and translucent; afterwards they become opaque, yellow and caseous.

The eruption of the tubercles is sometimes accompanied by a catarrhal exudation.

A lung studded with miliary tubercles is generally hyperaemic; it is firmer and contains less air than normal, the smaller nodules are grey and translucent, the larger opaque and white or yellow. The tubercles are thus obviously not all of the same age.

Embolic localised tuberculosis is in its origin of the same nature as the miliary form, but is distinguished from it by occurring only in one or two isolated patches.

The development of the single patch corresponds to that of the disseminated miliary eruption. As the patient usually survives for a longer time, the tubercles as they form coalesce into large nodular formations which are the starting-points for further morbid change (Art. 612).

Many writers have maintained the existence of a form of lobar pneumonia of which the regular termination is in caseation, and which they consequently describe as caseous lobar pneumonia.

Buhl (*Lungenentzundung Tuberculose und Schwindsucht* Munich 1872) has asserted that this caseous pneumonia is a sequel of what he calls true desquamative pneumonia. This latter begins acutely like croupous pneumonia and terminates in recovery, or after weeks, months, or years, in death. The gravest form ends in caseation and is the local expression of a 'tuberculous constitution.' As we have pointed out in Art. 604, there is no distinct form of pneumonia possessing the characters which Buhl describes, and the same holds true for the so-called 'caseous lobar pneumonia.' What has been so frequently described under this head is a confluent caseous lobular bronchopneumonia of tuberculous origin. Ziegler has examined a large number of lungs clinically described as the seat of caseous lobar pneumonia, and has always found them to be examples of nodular and lobular bronchopneumonia. Nauwerck and Koch have demonstrated the presence of tubercle-bacilli in the diseased foci (Nauwerck, *Deut. med. Woch.* 18, 1883; Koch, *Mittheil. a. d. k. Gesundh.* II 1884). For an account of the various views on the subject of caseous lobar pneumonia see Shepherd, *Brit. Med. Journ.* 1876; Hamilton, *ibid.* 1880; Orth, *Lehrb. d. spec. Path.* II Berlin 1885.

607. **Syphilitic pneumonia** occurs most frequently as the result of congenital syphilis, rarely in the acquired disease.

As we have already seen (Art. 128), when the poison of syphilis is diffused by way of the circulation it sets up inflammations which in some cases differ little from ordinary non-specific forms, in others are characterised as specific by the formation of gummatous foci. Both forms occur in the lung, but are certainly very rare indeed (if we except congenital syphilis), and this specific character is by no means easily established.

Gummatous pneumonia is a syphilitic inflammation of the

lung in which caseous granulomatous foci develope within patches of inflamed pulmonary tissue or of new-formed and hyperplastic fibrous tissue. Similar foci are often described as met with in post-mortem examinations, but there is little doubt that in most cases they are not due to syphilis. They are in general merely encapsuled patches of bronchopneumonia, dilated bronchi filled with caseous exudations, caseous detritus lying within dilated and thickened lymphatics and surrounded by new-formed fibrous tissue, and so on.

Gummata are extremely rare in the lungs of adults; they are commoner in new-born syphilitic infants, and may occur in considerable numbers. When recent they are grey or greyish-white and somewhat translucent; they vary from the size of a pea to that of a hazel-nut. Afterwards the centre becomes white and opaque, and by disintegration may even become excavated.

Another form of syphilitic pneumonia in infants gives rise to diffuse cellular inflammation of the lung, often accompanied by desquamation and fatty degeneration of the pulmonary epithelium. The diseased tissue is abnormally hard and white, and the affection has therefore received the name of **white pneumonia**.

Some writers describe a similar form in adults as the result of acquired syphilis, and it is said occasionally to lead to fibroid induration of the lung. According to PANKRITIUS it usually starts from the hilum and extends radially. Others describe as syphilitic certain indurative inflammations starting from the pleura or the interlobular septa.

Some of these inflammatory indurations in syphilitic subjects are no doubt due to the specific influence of the disease, but it is very difficult to distinguish them with any certainty. We may be sure that many of the indurative changes in the lung set down to syphilis have really no connexion with it, but are due to other causes. The like is true of many of the so-called syphilitic cicatrices of the lung, the pleura, and the interlobular septa.

On syphilitic bronchopneumonia see Art. 618.

VIRCHOW has expressly called attention to the fact that the diagnosis of syphilitic changes in the lung is of exceptional difficulty: he thinks however that both gummatous and simple irritative inflammations of the lung due to syphilis do occur. Among the latter are certain forms of fibrous pneumonia, pleurisy, and peribronchitis, and of catarrhal and caseous bronchopneumonia. Although of late years much has been published on the subject of pulmonary syphilis it cannot be said that our knowledge of its morbid anatomy has much advanced. Most of the cases described leave room for considerable doubt as to their syphilitic nature.

References:—DEPAUL, *Gaz. des hôpitaux* 1851; HECKER, *Virch. Arch.* vol. 17, *Berl. geburtshülfl. Gesellsch.* VIII (1854); E. WAGNER, *Arch. d. Heilk.* IV (1863); FORSTER, *Würzburg. med. Zeitschr.* IV (1863); VON BARENSPRUNG, *Hereditäre Syphilis* Berlin 1864; VIRCHOW, *Virch. Arch.* vols. 1 and 15, *Krankhafte Geschwülste* II (1865); HOWITS, *Arch. f. Syphilidologie* III; ANDREAE, *Anat. Unters. üb. d. Lung. syph. Kinder* In. Diss. Würzburg 1875; SCHÜTZ, *Syphilome d. Lunge*, *Klebs' Beiträge z. path. Anat.* I 1878; VIERLING, *Deut. Arch. f. klin. Med.* XXI; COLOMATTI, *Arch. f. Derm. u. Syph.* V (1878);

PAWLINOFF, *Virch. Arch.* vol. 75; SCHNITZLER, *Die Lungensyphilis* Vienna 1880; GRANDIDIER, *Berl. klin. Woch.* 1875; GERHARDT, *Sitzungsber. der phys.-med. Gesellsch. z. Würzburg* 1881; RAMDOHR, *Arch. d. Heilk.* XIX; THOMPSON, *Lancet* 1, 1878; SACCHARJIN, *Berl. klin. Woch.* 1878; TIFFANY, *Amer. Journ. med. sciences* 1877; PANKRITIUS, *Ueb. Lungensyphilis* Berlin 1881; GUNTZ, *Memorabilien* 1882; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884; KOPP, *Deut. Arch. f. klin. Med.* XXXII; HILLER, *Charité-Annalen* 1884 (with critical summary of published cases); BIRCH-HIRSCHFELD, *Lehrb. d. path. Anat.* II 1884; GOODHART and others, *Trans. Path. Soc.* XXVIII.

608. **Pleurogenous pneumonia.** When the pleura becomes affected with inflammation (pleurisy) the underlying pulmonary tissue may be injured, either mechanically (Art. 591) or by extension of the inflammatory process to the lung. The extension takes place chiefly by way of the lymphatics, which are very abundant in the pleura and communicate directly with those of the interlobular septa. The first sign of the inflammation is exudation into the lymphatic vessels, by which they are distended—often to the dimensions of a middle-sized bronchus.

Interlobular lymphangitis of this kind may result from various types of inflammation, though it is most commonly associated with purulent or fibrino-purulent pleurisy, whether set up by pyaemic (embolic) suppuration in the lung or as a primary local affection. For example, it is not infrequently met with in infants who have died of pyaemia from septic infection of the umbilicus.

The distention of the interlobular lymphatics with purulent or fibrino-purulent exudation causes the lobules to be separated by zones of yellowish-white infiltrated tissue, and if the septa themselves undergo suppuration the lobules may be loosened and isolated from each other. This form of pulmonary inflammation is accordingly spoken of as **dissecting pneumonia** (HUTINEL and PROUST, *Archives générales de méd.* 1882).

From the septa the inflammation may spread to the peri-bronchial lymphatics and affect them in a similar way. The lobules also may become inflamed, so that the already compressed lung-tissue becomes the seat of inflammatory exudation and infiltration—catarrhal, croupous, haemorrhagic, or purulent—as the case may be. Accordingly the lobules may look red, greyish-red, or greyish-yellow, and saturated with a turbid secretion. The appearance of the lung is in fact like that of an ox dead of pleuro-pneumonia (Art. 605).

If the disease is not fatal, recovery takes place by resorption, though in most cases there remains some permanent thickening of the interlobular tissues. Should residues of inspissated pus remain in the thickened septa, nodules having much resemblance to gummata are formed and have occasionally been mistaken for them.

Tuberculosis may in like manner extend from the pleura to the lung, as in cases of tuberculous disease of the ribs or vertebrae; and then tubercles appear along the course of the several lymphatics.

Chronic indurative and plastic inflammations of the pleura may

also extend to the alveoli by way of the interlobular and peribronchial channels.

The thickening of the pleura causes *the lung to be enclosed in* a thick, tough, fibrous casing (Fig. 232 *a*) *from which stout fibrous* bands (*c*) (corresponding to the interlobular septa) extend into the



FIG. 232. CHRONIC PLEUROGENOUS INTERLOBULAR PNEUMONIA.

(*Hardened in Müller's fluid, stained with picrocarmine* : × 3·5)

a thickened pleura
b pulmonary tissue
c thickened interlobular septa
d cellular infiltration at the boundaries of the thickened septa
e dilated bronchus with infiltrated mucous membrane *f* and thickened peribronchial tissue
g bronchioles with infiltrated walls

pulmonary tissue, forming a kind of coarse meshwork with the thickened peribronchial tissue (*e*).

The pulmonary tissue enclosed in the meshes of the septa is more or less compressed, and sometimes becomes entirely collapsed and functionless. Moreover active inflammation may extend from the septa to the alveoli (*d*) and give rise to infiltration and fibrous hyperplasia in them. Very frequently too the morbid process is associated with evidences of bronchopneumonia, either primary, secondary, or antecedent.

The bronchi of the affected region seldom remain entirely healthy. As a rule they are distorted and dilated (*e*), partly owing to the traction of the shrinking fibrous tissue, partly to the pressure of the air which is irregularly distributed among the alveoli. There is usually also some bronchial catarrh, the mucous membrane both of bronchi (*f*) and bronchioles (*g*) being visibly infiltrated.

609. **Inflammation of other contents of the thorax** or of the abdomen sometimes extends to the lungs. The mediastinal organs, the bronchial glands, the oesophagus, the stomach, and the liver, are the parts most commonly concerned. And according to the character of the primary affection the inflammation of the lung may be purulent or putrid, tuberculous, caseous, or indurative. Thus a tuberculous gland may give rise to tuberculosis of the root of the lung, and an abscess of the liver breaking through the diaphragm may cause suppuration of the base of the lung with purulent pleurisy or empyema.

In ulcerative disease of the lung the bronchi may become perforated. A basal abscess, for instance, or a broken down caseous bronchial gland, may rupture into a neighbouring bronchus. If the matters thus evacuated are infective or irritating, and if some of them are aspirated into other parts of the parenchyma of the lung, secondary bronchopneumonia may result (Art. 613).

Traumatic lesions of the lung, caused for example by a fractured rib, give rise in the first place to haemorrhage and perhaps entrance of air into the pleural cavity (pneumothorax). If the wound is not contaminated the rent is healed by thrombosis and subsequent cicatrisation. Septic contamination of the wound results in suppuration and gangrene of the lung.

CHAPTER LXXXVII.

FORMS OF BRONCHOPNEUMONIA.

610. **Non-specific bronchopneumonia.** All forms of bronchopneumonia are at first essentially local disorders, whose extent and distribution are determined by the position and relations of the affected bronchioles and alveolar ducts. This local character is most apparent when the irritant substance which induces the bronchopneumonic inflammation is in a minutely divided form and suspended in the inspired air, so that it reaches the terminal air-

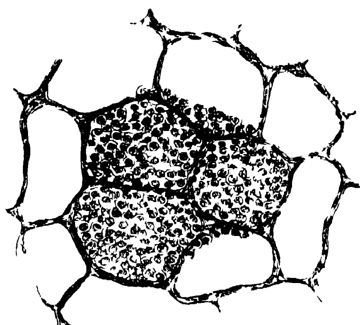


Fig. 233.

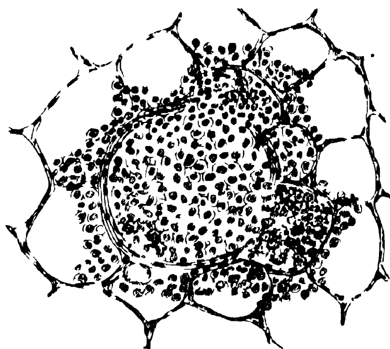


Fig. 234.

Fig. 233. Miliary bronchopneumonia.

A patch extending over three alveoli.

(*From the lung of a dog, after inhalation of an irritating spray*. × 30)

Fig. 234. Miliary bronchopneumonia.

A patch extending over a respiratory bronchiole and the adjacent alveoli : some of the extravasated cells contain particles of dust.

(*From the same lung*)

passages directly. In animals such inflammations can readily be produced by causing them to breathe an atmosphere containing irritant substances in the form of dust or spray. In man the earlier

stages can be observed only in cases where shortly before death a quantity of irritating dust, or very small particles of secretion from the air-passages themselves, have been inhaled.

Wherever these particles lodge an acute reactive inflammation is set up around them, first of all in the wall of the particular air-space, and soon (if the irritation be sufficiently great) in the adjoining tissue also. In this way are formed minute, or as they are called miliary, patches of inflammation starting from the terminal air-sacs or infundibula (Fig. 233), or from the alveolar ducts and respiratory bronchioles (Fig. 234) with their alveoli, and spreading to the neighbouring elements by direct extension.

When the aspirated substances are still more irritating (*e.g.* saliva with remains of food, pus from laryngeal abscesses, etc.), the inflammations induced are more extensive. In this way are produced larger areas of bronchopneumonia extending over a number of contiguous alveoli, alveolar ducts, and bronchioles. When entire lobules are thus attacked we have what is called **lobular bronchopneumonia.** When all or most of the lobules of a lobe are simultaneously affected we have what may be called **lobar bronchopneumonia.**

The appearance of the bronchopneumonic patches naturally varies with the form of the inflammation (Arts. 596, 597) and the stage it has reached. When exudation has followed upon the initial hyperaemia, the spots have a dark-red, greyish-red, grey, or greyish-yellow tint, and yield on pressure a turbid liquid whose tint varies in like manner, according to the proportion of red and white blood-cells it contains. Only in croupous inflammations is the exudation solid or semi-solid and not readily squeezed out. The cut surface has a granular look. The inflamed patches are sometimes well-defined, sometimes indistinct. The tissue around them is usually hyperaemic.

In miliary bronchopneumonia when the cellular infiltration is dense and the patches sharply-defined, they sometimes look very like recent miliary tubercles.

Very frequently indeed bronchopneumonia is preceded by bronchitis and bronchiolitis, and thus before the respiratory tissue is actually inflamed some of the smaller bronchi may be obstructed and so give rise to lobular collapse or atelectasis (Art. 591). The collapsed lobules assume a dark-red or livid tint, and thus the onset of bronchopneumonia in them is not very obvious. The tint alters only after a certain amount of cellular and serous exudation has taken place into the alveoli, and then the characteristic turbid juice can be squeezed from the affected tissue.

611. The **number and distribution** of the bronchopneumonic centres will of course be very different in different cases. In one instance they may be scattered over both lungs, in another confined to a part of a single lobe. When a large number of lobules are collapsed or inflamed, compensatory dilatation of the still active

lobules takes place. Subpleural inflammations usually lead to inflammation of the pleura also.

Suppuration and gangrene of the bronchopneumonic patches are comparatively infrequent; they are most commonly due to the aspiration of irritating liquids from the mouth or stomach, or of pus and detritus from abscesses or ulcers in the larynx or trachea, from cavities in the lung itself, and so on. As in the case of embolic abscesses and necroses, these **bronchopneumonic abscesses** may heal more or less completely by delimiting inflammation and cicatrisation. Death however is the more frequent result.

In most cases of bronchopneumonia the exudation is absorbed, and the lung restored to its normal state. It must however be remembered that unabsorbed residues are much more common after bronchopneumonia than after croupous pneumonia. Even in the non-suppurative forms the cellular infiltration of the interlobular and peribronchial fibrous structures is here and there so abundant that complete resorption is impossible: the circulation of the part may indeed be so much interfered with that caseous necrosis takes place. In other cases the inflammation persists for a considerable time, and passing into a chronic condition leads to the formation of new fibrous tissue and thus to induration.

Dry **caseous necrosis** of the pulmonary tissue occurs generally as a sequel of the lobular inflammation, especially in children suffering from bronchitis and bronchopneumonia after measles or whooping-cough. It may however occur in adults and in connexion



FIG. 235. MASON'S LUNG WITH BRONCHOPNEUMONIC FIBROUS NODULES.
(*Section hardened in alcohol, and stained with picrocarmine* : × 9)

group of fibrous nodules
normal pulmonary tissue
c thickened pulmonary tissue containing bronchi, vessels, and a few alveoli

with other forms of bronchopneumonia. While many of the patches of inflammation disappear by resorption, here and there the exudation persists, condenses, and by degrees assumes a dry cheesy

consistence, while the surrounding tissue simultaneously undergoes necrosis. In this manner caseous nodules, from the size of a pea to that of a walnut, are produced; after a time they become enclosed in a fibrous capsule, and then may remain for an indefinite time without further change, though frequently they become calcified. These nodules are met with in all parts of the lung, though the apex is the commonest seat. Occasionally they give rise to obstruction of some of the bronchial tubes (Art. 580).

A more frequent result of bronchopneumonia is induration or **cirrhosis of the lung.** In its least-complicated form this occurs in cases where the continual inhalation of irritating dust keeps up a constantly-renewed inflammation.

Coal-dust is the least irritating, stone-dust and metallic particles are much more injurious. The power of the absorbents is usually insufficient to remove all the dust inhaled, and inflammation being set up around the particles that remain in process of time they are enclosed in capsules of new fibrous tissue (Fig. 235 *a*), and thus give rise to hard fibrous nodules.

In some cases these nodules are few and scattered: in others they are numerous and lie together in groups (Fig. 235). Instances occur in which they are so numerous in particular parts of the lung that scarcely any air-containing tissue exists between them, and in other parts the lung is entirely fibrous. This condition is best described as **nodular cirrhosis.**

The separate nodules are of various sizes from that of a lentil to that of a bean. They are white, slate-coloured, or even black, and that even in the absence of coal-dust. The pigment is then derived from the colouring-matter of the blood. When fully developed they consist of coarse fibrous tissue, often concentrically stratified. Larger nodes are formed by the coalescence of smaller nodules, and correspond to the territory of a single bronchiole: the smallest nodules represent terminal alveoli or infundibula.

The tissue round about the nodules is infiltrated with cells, or thickened and fibrous, the indurative inflammation extending radially.

When the bronchopneumonia is lobular, and associated with obstructive collapse, the nodular cirrhosis is accompanied by a more diffuse indurative change, which we may call **lobular cirrhosis.** In this way, as in the cirrhosis of simple collapse (Art. 592, Fig. 221), the lung is beset with patches of compact grey or slate-coloured tissue, enclosing scattered nodules which are usually of a paler tint.

Patches of this kind may be formed in any part of the lung, though they are most common at the apex : not infrequently they contain small cheesy nodules.

The pervious bronchi traversing the indurated region generally become dilated, and are the seat of chronic inflammation often of an ulcerative kind and leading to the formation of cavities or

vomicae. When such a vomica contains a decomposing or irritant secretion, the latter may gain access to the air-passages and by aspiration pass into the terminal branches of other bronchi. In this way fresh bronchopneumonia is set up, and may lead to miliary or nodular or lobular inflammation, ending in local recovery, or it may be in suppuration or induration like the first.

The pleura is affected in all bronchopneumonic indurations that are not entirely limited to the deeper parts of the lung; thickening and adhesions are the usual result. So also it is not unusual to find thickening of the peribronchial and the interlobular fibrous tissue.

612. **Tuberculous bronchopneumonia**. Tuberculosis of the lung may begin in one of three ways: namely, as embolic tuberculous pneumonia, as primary tuberculous bronchopneumonia, and as tuberculous lymphangitis.

Embolic tuberculous pneumonia has already been considered (Art. 606). It takes the form either of disseminated miliary tuberculosis and terminates fatally, or of a localised affection leading to the formation of one or more isolated caseous nodes. These nodes may occur either in a part of the lung previously healthy, or in tissue already altered by disease.

Tuberculous lymphangitis (Art. 609) takes the form of a local eruption of tubercles in the neighbourhood of a tuberculous focus outside the lung. A caseous bronchial gland or tuberculous disease of the vertebral column is the commonest starting-point of the affection.

Primary tuberculous bronchopneumonia attacks both healthy and diseased lung-tissue.

In the former case tubercle-bacilli, either alone or accompanied by other irritant matters, gain access with the inspired air to the respiratory parenchyma, settle in some ramification of the air-passages, and in the first instance give rise to a nodular patch of inflammation (Fig. 236 *g*). Occasionally the bacilli may at once be taken up by the lymphatics and give rise first in them to the formation of granulomatous nodules.

When the tubercle-bacilli alone enter the lung, these are the only changes induced; but if at the same time other sources of irritation are at work the tuberculous changes are accompanied by more or less extensive bronchitis and bronchopneumonia. As the case goes on the latter affections pass away, often however leaving behind bronchi obstructed with secretion, or collapsed and indurated patches sometimes containing caseous foci; so that the affected part of the lung includes one or more caseous patches (*e*) containing bacilli, caseous masses free from bacilli, obstructed or occluded bronchi, and grey cirrhotic areas. In certain cases patches originally containing bacilli may become free from them, and undergo cicatrisation with or without caseous enclosures.

The specific infection frequently reaches a lung already

morbidly affected. If the affection is a recent bronchitis with bronchopneumonia, the after-course of the disease will resemble that just described. Exactly how often such a secondary infection

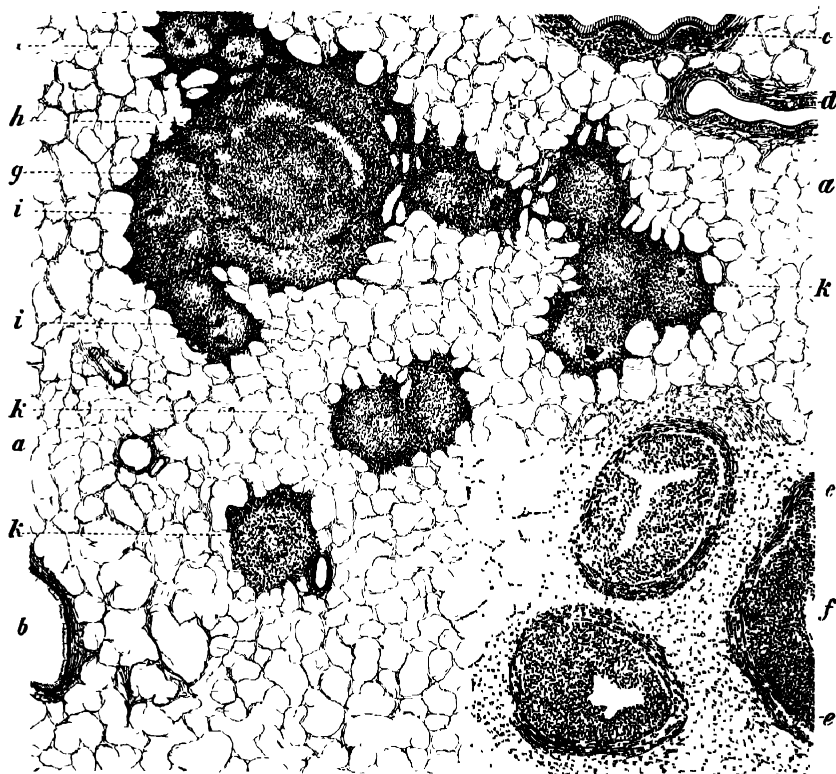


Fig. 236. Primary tuberculous bronchopneumonia with commencing tuberculous lymphangitis.

(*Section from the left apex of the lung of a woman of* 25, *which contained a few scattered nodes with central caseation; carmine staining:* × 15)

a normal lung-tissue
b normal bronchus
c bronchus with inflamed wall
d artery
e encapsuled caseous bronchopneumonia
f fibroid induration
g caseous centre and
h cellular periphery of a tuberculous node
i k tubercles in the neighbouring lymphatic vessels

takes place it is not at present easy to determine. Most probably we have instances of it in those cases where chronic tuberculosis appears to be developed from a non-tuberculous bronchopneumonia such as follows measles or whooping-cough.

Secondary tuberculous infection is also favoured by the fact that inhaled bacilli may develope more readily in tissue which is altered by antecedent or still persisting chronic inflammatory processes. This possibility is supported by the observation—that

certain tissue-changes connected with particular inflammatory affections of the lung appear to predispose it to tuberculosis. So far as can be made out by morbid anatomy these are chiefly—caseous necrotic patches, inspissated collections of bronchial secretion, and bronchiectatic cavities. The predisposition does not depend on the way in which these morbid changes have been brought about. When the bacilli once gain a settlement the periphery of the caseous node or the wall of the bronchiectatic cavity becomes the seat of a new inflammation which thenceforth exhibits the character of a tuberculous process.

The author has for a number of years endeavoured from the anatomical side to make out the early stages of pulmonary tuberculosis, and the above account represents the outcome of his investigations. In Würzburg and in Zürich he had to make post-mortem examination of a large number of children and young persons, and so had frequently the opportunity of observing tuberculosis in all its stages, even from the very beginning. He has thus convinced himself that in the great majority of cases tuberculosis of the lung begins in the form of solitary nodes or nodular foci. The tuberculous nature of these foci is in general readily determined from the appearance of the parts immediately around them. Recently also NAUWERCK and GLASER have demonstrated the presence of tubercle-bacilli in some of the cases collected by the author.

The occurrence of secondary tuberculous infection in lungs already diseased appears to follow from the frequently-observed fact that recent tuberculous bronchopneumonia is found side by side with old patches of induration that are devoid of any recognisably tuberculous character, while the bronchiectatic cavities they enclose contain tubercle-bacilli. It must however be granted that a tuberculous lung may recover locally, the disease sometimes leaving behind it patches of induration that possess none of the special characters of tuberculosis.

Formerly attempts were made to explain pulmonary phthisis and tuberculosis as the direct result of a special **constitution** or predisposition, which reacted in a peculiar way to ordinary irritations. After the communicability of tuberculosis was established stress was always laid on the fact that certain animals are more susceptible of the disease than others, and accordingly the special predisposition of the individual has always been regarded as a principal factor in the genesis of tuberculosis. Since KOCH's discovery of the tubercle-bacillus the question of predisposition has fallen somewhat into the background. It appears however unwise to lose sight of what is almost certainly the fact—that many persons are more disposed to become tuberculous than others. This predisposition is either congenital or acquired, and consists either in local alterations of tissue or in the general constitution of the system, that is in peculiarities of the metabolism of the tissues. For instance, diabetic patients are well-known to be very apt to suffer from a fatal form of tuberculous phthisis. Other predisposing conditions are—excessive smallness of the heart in proportion to the lungs and the body generally, poverty of the blood in albuminoids and water such as follows continued lactation, suppuration, cholera, etc., lesions of the heart limiting the blood-supply to the lungs, contracted thorax, and enfeebled inspiration. Scrofula, that is to say the particular anomaly of constitution which is manifested chiefly by a tendency to chronic catarrh of mucous membranes, also favours tuberculous infection. How exactly these conditions act as predisposing causes of tuberculosis we can hardly at present determine, though all clinical experience goes to show that they are of some importance.

In addition to the constitutional predisposition we have to consider the **local predisposition**; and it is reasonable to suppose that in the case of the

lung this latter plays a considerable part. Thus lung-tissue that is inflamed or that is altered in a certain way by previous inflammation is more apt to become tuberculous than normal healthy tissue.

Lastly, it appears certain that many persons are predisposed or rather predestined to tuberculosis because they are much more exposed to the chances of infection than others. This is especially the case with children who grow up in the company of tuberculous parents.

An extremely important, but at present involved, question is—whether tuberculosis can be **inherited**, *i.e.* whether the tubercle-bacillus can be transmitted from the parent to the foetus in fecundation or during gestation. ZIEGLER has pointed out in several of his writings that no anatomical facts are yet to hand in support of the affirmative supposition. There is on record no indubitable instance of intra-uterine foetal tuberculosis, and after birth the affection appears at the earliest in the third week, by which time it is quite possible for infection from without to have taken place. It must however be kept in mind that in some instances the disease had at this time made such progress that the beginning of it might with great probability be referred to the intra-uterine period (DEMME and LICHTHEIM, *Verhandl. d. med. Congresses in Wiesbaden* 1883). ZIEGLER'S view is—that **congenital tuberculosis** is possible but not yet certainly demonstrated, and that it must at any rate be rare. Since KOCH'S discovery a good many authorities have come over to this view. Actual transmission of tuberculosis to the foetus appears conceivable only when at the time of impregnation the male suffers from urogenital tuberculosis, or when during gestation the female genital organs are tuberculous, or tubercle-bacilli gain access to the circulatory system. Future observation alone can determine whether this view is correct or not, and meanwhile we may explain the fact—that the children of tuberculous parents so readily perish from tuberculosis—by observing that they inherit some predisposition to the disease and by their constant intercourse with the parents are in a special way exposed to the risk of infection.

Tuberculosis by **inhalation** was first induced in animals by TAPPEINER, LIPPL, and SCHWENINGER (*Naturforscherversammlung in Munchen* 1882, *Virch. Arch.* vols. 74, 82), afterwards by WEICHSELBAUM (*Cent. f. med. Wiss.* 1882, *Wiener med. Jahrb.* 1883), SCHOTTELIUS (*Virch. Arch.* vol. 73), and others. When animals are made to breathe air containing phthisical sputa pulverised by means of the spray-apparatus, small miliary bronchopneumonic patches much resembling tubercles are found in the lungs. TAPPEINER took them for actual tubercles and compared them to the tubercles found in miliary tuberculosis of the lung. This however is a mistake: they are multiple primary tuberculous bronchopneumonic patches of miliary size, caused by the inhalation of tubercle-bacilli (ZIEGLER, *Sammlung klin. Vortrage* 151). VERAGUTH worked at the subject in ZIEGLER'S laboratory during 1881—82, and showed that in the bronchopneumonic patches great masses of bacilli were developed, that in course of time from these patches were formed larger caseous and even ulcerating nodes, and that in goats the process might give rise to tuberculous disease of the lymphatics, lymphatic glands, and serous membranes, all of which contained bacilli. Fourteen days elapse from the time of inhalation before the first visible changes are detected. As the changes set in masses of bacilli are seen in the alveolar epithelial cells, which they presently cause to degenerate, while reactive inflammation is set up in the adjacent tissue.

References:—BAYER, *Études compar. de la phthisie pulmonaire* 1842; SEEGEN, *Der Diabetes mellitus* Berlin 1878; BOUCHARDAT, *De la glycosurie* Paris 1878; LEYDEN, *Ueb. diabet. Lungenphthise, Zeitschr. f. klin. Med.* IV; RÜHLE, *Ziemssen's Cyclop.* V; JURGENSEN, *ibid.*; ZIEGLER, *loc. cit.*; BAUMGARTEN, *Zeitschr. f. klin. Med.* VI, *Sammlung klin. Vortrage* 218, *Berl. klin. Woch.* 1883; *Collective Investigation Record* I London 1883; KLEBS, Art. *Tuberculose, Eulenburg's Encyclopadie* XIII; VERAGUTH, *Arch. f. exp. Path.* XVII 1883; KOSTER, *Sitzungsber. d. niederrhein. Gesellsch.* Bonn Feb. 1876; SENISE, *Movimento med. chir. di Napoli* 4, 1883; JOHNE, *Geschichte d. Tuber-*

culose Leipzig 1883, and *Die käsige Hüttenrauchpneumonie d. Rindes, Fortschritte d. Med.* I 1883, III 1885; BIEDERT and SIGEL, *Virch. Arch.* vol. 98; WARGUNIN, *ibid.* vol. 96; WAHL, *Deut. med. Woch.* 1, 1885; SCHAFFER, *Die Verbreitung d. Tuberculose in den Lungen* In. Diss. Berlin 1884; BREHMER, *Die Aetiol. d. chron. Lungenschwindsucht* Berlin 1885.

613. **Extension of tuberculosis in the lung.** The manner in which tuberculosis of the lung extends from part to part is always the same, whether the original infection is due to embolism or to inhalation.

The first-formed nodule increases in size by **peripheral extension** of the cellular infiltration. The accumulation of cells in the contiguous alveolar walls and alveoli takes place continuously and uniformly (Fig. 236 *h i*), though here and there we may find typical tubercles with epithelioid cells and giant-cells in the midst of the mass of simple leucocytes.

After a certain time this continuous extension is accompanied by **tuberculous lymphangitis**, manifested by the development of tubercles in the course of the surrounding lymphatics (Fig. 236 *i k*). This eruption may be interalveolar, interlobular, or peribronchial, and often spreads rapidly to the pleura and the bronchial glands.

In many cases this is the only mode of extension, at least for a considerable time. For months together, either steadily or with occasional pauses, fresh nodular foci continue to be formed along the course of the lymphatics, and the intervening tissue becomes chronically inflamed. In this way patches of induration of various sizes are produced, which contain single tubercles and groups of tubercles, usually all enclosing bacilli, and in various stages of growth and decay.

Sooner or later another mode of extension takes place in addition to this ordinary one of lymphangitic induration and caseation.

A primary (or it may be a secondary) caseous node reaches a certain size, softens and disintegrates, and then breaks through into a bronchus. The caseous detritus contains tubercle-bacilli, and consequently a possibility arises that the disease may be spread to other parts of the lung by **aspiration** into the air-passages. As a fact much of the detritus and the bacilli are coughed up as sputum, but some may be aspirated into the smaller tubes and so reach the respiratory parenchyma This may also happen when the infected contents of a bronchiectasis or of a bronchiectatic vomica are emptied into a bronchus, or when a cheesy tuberculous gland softens and breaks through.

The aspirated matters lodge in various parts of the pulmonary tissue and give rise to a reactive inflammation whose extent and intensity depend partly on the amount and nature of the irritant substances, partly on the relations of the tissue involved, partly on the special predisposition of the patient. As regards the irritant

substances it must be kept in mind that they often include not only tubercle-bacilli but also other micro-organisms and chemical products of decomposition from the diseased cavities, and these may give rise to suppurative, or fibrinous, or even putrid inflammations.

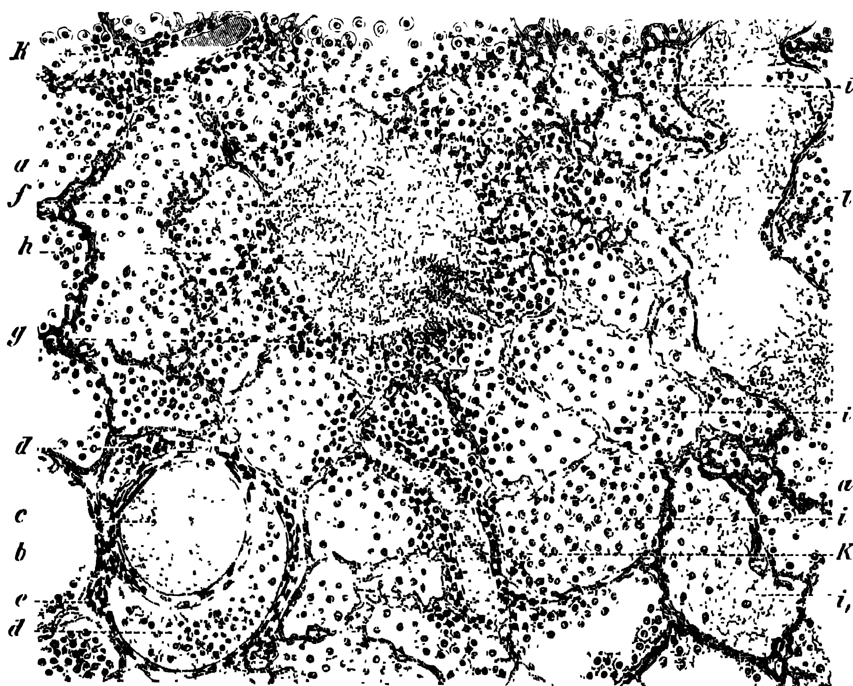


Fig. 237. Miliary tuberculous bronchopneumonia.

(This is a secondary patch due to the aspiration of the contents of a small caseous node which ruptured into a bronchus: preparation injected with blue gelatine and stained with alum-carmine: the bacilli drawn from a parallel section stained with fuchsin: × 80)

a interalveolar septa with injected capillaries
b respiratory bronchiole
c injected artery
d circumvascular lymphatic distended with exudation
e pigment lying round the lymphatic
f caseous centre, and
g cellular periphery of the bronchopneumonic patch
h tubercle-bacilli (× 160)
i cellular exudation in the alveoli
i_1 chiefly fibrinous exudation
k vein with surrounding cellular infiltration
l interlobular lymphatic distended with exudation

In this way a fresh focus of bronchopneumonic inflammation is lit up. The course of the new inflammation is in general this—there is first an abundant cellular exudation; after some days or weeks this forms a nodular infiltrated patch (Fig. 237 *f g*), which then becomes caseous in the centre (*f*), while the periphery (*g*) consists of living cells. By proper staining-methods bacilli (*h*) can be shown lying singly or in groups both in the caseous and

in the cellular parts. The vessels which traversed the part occupied by a solid nodule of this kind are always destroyed.

The lung-tissue around the nodule is the seat of an exudative inflammation, whose intensity differs greatly in different cases. As a rule the neighbouring alveoli (*i*) contain extravasated liquid and cells, desquamated epithelium, and often fibrin (i_1). The alveolar walls are infiltrated with leucocytes, especially around the veins (*k*). The lymphatics, peribronchial and periarterial (*d*) as well as interalveolar and interlobular (*l*), are also in some measure affected by the inflammation, being more or less distended by exuded matters (*d l*). When the nodule is subpleural, the pleura is simultaneously inflamed.

When a number of tuberculous bronchopneumonic foci are thus formed by aspiration, each passes through much the same series of changes as were described in the case of the primary focus. Some continually enlarge and lead to progressive tuberculous lymphangitis, others soften and break down and by aspiration of their contents lead possibly to fresh bronchopneumonic infection.

At all stages of the disease there is still another possible mode by which the infective agent may be disseminated. Chronic inflammatory change in the lung always extends in some degree to the blood-vessels. Plastic inflammation leads to fibrous thickening of the walls of arteries and veins, and by endarteritic thickening some of the smaller branches may be obliterated altogether. In tuberculous inflammation of the lung the walls of the capillaries as well as those of the arteries and veins are especially apt to be affected. When an actual tuberculous node or nodule is formed the capillaries perish outright, while in the walls of the larger vessels appear granulomatous growths having all the characters of tubercle, and developing some into fibrous thickenings and some into caseous ulcers. These several morbid changes naturally lead to local disorders of the circulation, and to more or less copious haemorrhages (**haemoptysis**), which are most apt to follow when the walls of arteries are diseased and are eroded or give way. But there is also the danger that the caseous growths on the walls of veins may break into the interior of them, and permit the tuberculous detritus and bacilli to enter the circulation and spread the infection to distant organs. This however appears not to happen at all frequently, no doubt because before a tubercle actually breaks through the intima into the vein thrombosis is induced by the diseased state of the wall, and in this way the vein itself is effectually blocked up (compare CORNIL, *Journ. de l'anat.* 1880; MUGGE, *Virch. Arch.* vol. 76; ARNOLD, *ibid.* vol. 88; WEIGERT, *ibid.* vols. 77, 87, 104).

The tubercle-bacilli may at a very early stage of the disease pass from the peribronchial lymphatics into the bronchial glands, and there set up tuberculous changes. Cases indeed not infrequently occur in which only a few scattered bronchopneumonic

nodules are found in the lungs, while some of the bronchial glands are tuberculous throughout or entirely caseous. It has even been noted that only a single small patch may occur in the lung, or that no patch at all may be discovered, and yet the bronchial glands may be extensively diseased.

After the tuberculous process has spread over a considerable part of the lung and the lymphatics the bronchi also become diseased in like manner. The smaller tubes are first affected, then the larger, and often the trachea and larynx as well. If the sputum be swallowed tuberculosis of the alimentary canal may be set up.

The author in a lecture published in 1878 (*Sammlung klin. Vorträge* 151) explicitly insisted on the fact that the extension of tuberculosis in the lung takes place by way partly of the lymphatics and partly of the bronchial passages, the whole course of the disease suggesting inevitably that the secretion and other contents of tuberculous cavities act infectively upon the sounder parts of the lung. This statement was based chiefly on the results of anatomical examination and on the experiments on inhalation cited in Art. 612. The subsequent discovery of the tubercle-bacillus, and the demonstrated fact that the sputum from the diseased lung contains bacilli, corroborate the statement, and all the author's recent observations in the post-mortem room are in entire accord with it. When a number of tuberculous bronchopneumonic patches are found in a lung, there is always present an older disintegrated focus or a bronchiectasis or a caseous lymphatic gland: in these the bacilli have multiplied and have thence been disseminated along the air-passages.

We are unable to set forth in detail the numerous and various accounts which have been given of tuberculous disease of the lung. An analysis of them could only be of value if accompanied by the arguments which have induced us to set aside those that differ from the account in the text, and this would scarcely be in place in a work like the present. In general terms it may be said that some of the views referred to are erroneous because they rest on mistaken ideas as to the structure of the lung; and further that sufficient attention has not been paid to the distinction between diseases of the respiratory parenchyma of the lung and diseases of the bronchi and peribronchial tissue. Many affections have thus been described as peribronchitic in which the peribronchial tissue is intact, the affection being really one of the respiratory tissue and only properly described as bronchopneumonic. Authors again have in many cases entirely ignored the lymphatics, while a few have exaggerated the part they play.

References on the morbid anatomy of chronic pulmonary tuberculosis:—LAENNEC, *Traité de l'auscultation médiate et des maladies des poumons et du cœur* II Paris 1837; CARSWELL, *Pathological Anatomy* London 1838; RUHLE, *Ziemssen's Cyclop.* V; RINDFLEISCH, *Pathological Histology* II London 1873; RAYMOND, *Arch. gén. de méd.* 1883; ORTH, *Virch. Arch.* vol. 86, *Berl. klin. Woch.* 1881; AUFRECHT, *Path. Mittheil.* I, II; KOSTER, *Sitzungsber. d. niederrhein. Gesell.* Bonn 1876; HUGUENIN, *Corresp. f. Schweizer Aerzte* 1880; ZIEGLER, *loc. cit.*; BUHL, *loc. cit.*; VON WYSS, *Gerhardt's Handb. d. Kinderkr.* III; HAMILTON, *Pathology of bronchitis etc.* London 1883; CORNIL and RANVIER, *Man. Path. Hist.* II London 1884; SORMANI, *Annal. univers. di med.* 1883; GERMAIN SÉE, *Bacillary phthisis* (trans. by WEDDELL) London 1885; ORTH, *Lehrb. d. spec. Path* II Berlin 1885.

References on tubercle-bacilli in sputum etc.:—KOCH, *Berl. klin. Woch.* 15, 1882 and 10, 1883; BAUMGARTEN, *Cent. f. med. Wiss.* 15, 1882; LICHTHEIM, *Fortschritte d. Med.* I (1883); DE GIACOMI, *ibid.*; BALMER and FRAENTZEL, *Berl. klin. Woch.* 45, 1882 and *Deut. med. Woch.* 17, 1883; HILLER, *Deut. med. Woch.* 47, 1882, *Zeitschr. f. klin. Med.* V; P. GUTTMANN, *Berl. klin. Woch.* 52,

1882; PFEIFFER, *ibid.* 3, 1883; ZIEHL, *Deut. med. Woch.* 5, 1883; MENCHE, *Fortschritte d. Med.* I; DRESCHFELD, *Brit. Med. Journ.* 1, 1883; DEMME, *Berl. klin. Woch.* 15, 1883; RIEGEL, *Cent. f. klin. Med.* 13, 1883; MÜLLER, *Verhandl. d. phys.-med. Gesell. zu Würzburg* XVIII (1883), *London Med. Record* 1885; KOCH, *Mitth. a. d. k. Gesundh.* II 1884; KLEIN and GIBBES, *Annual Report to Local Government Board* 1883–84; PERCY KIDD, *Med. chir. Trans.* LXVIII 1885; HUNTER MACKENZIE, *Treatise on the sputum* Edinburgh 1886; CORNIL and BABES, *Les bactéries* Paris 1885.

614. From what has been said in the last Article it will appear that the extension of localised tuberculosis of the lung is essentially a bronchopneumonic process, accompanied to a varying extent by lymphangitis, bronchitis, and peribronchitis.

All these inflammatory processes affect in the first instance

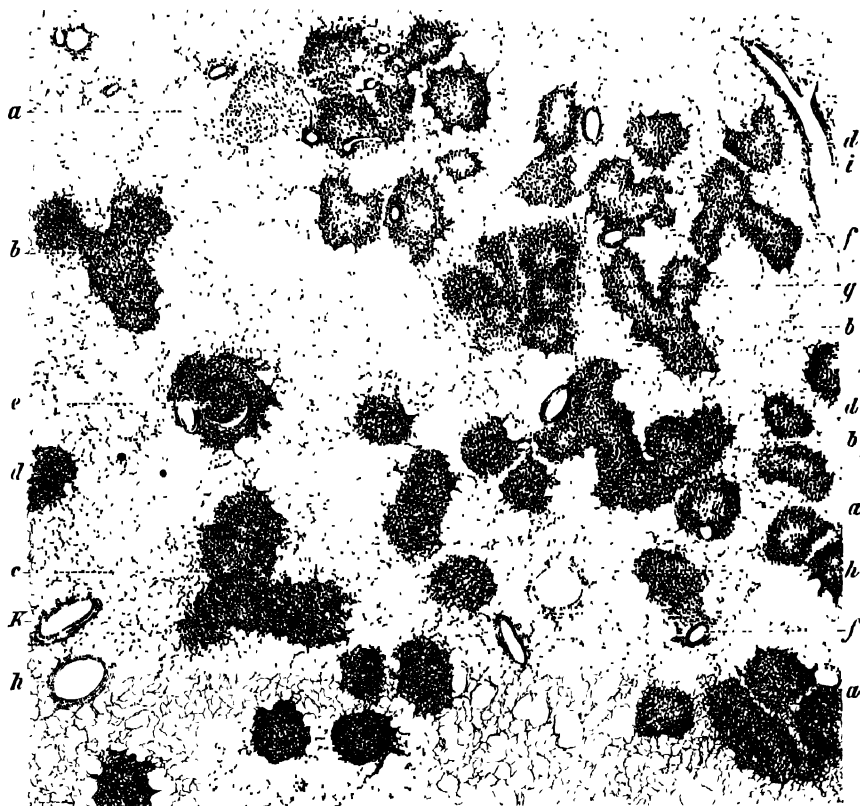


FIG. 238. CHRONIC NODULAR TUBERCULOUS BRONCHOPNEUMONIA.

(*Hardened in Müller's fluid, stained with picrocarmine*: × 6)

a b c d nodules of various forms corresponding to systems of alveolar ducts
e section through an infiltrated and occluded bronchiole
f arteriole
g nodules in process of coalescence
h small bronchus (normal)
k artery

more or less isolated patches of tissue, which are usually nodular and vary from the size of a millet-seed to that of a pea. Where the process is still recent we thus find the respiratory tissue studded with small grey translucent nodules, or larger white opaque ones (Fig. 238 *a d*). Most of these are simply respiratory bronchioles and alveolar ducts with their alveoli (*abcd*) which have become transformed by inflammation into compact and continuous masses. On section we can frequently make out in them the form and arrangement (*b c*) of the original parts. It is only when the nodule increases in size by the extension of the inflammation to neighbouring alveolar groups and to the lymphatics that this configuration becomes indistinct and disappears.

In the later stages the bronchopneumonic nodules usually give place in a measure to those caused by lymphangitis, bronchitis, and peribronchitis (*e*); but this is by no means always the case. Cases occur in which the thickening of the bronchi and peribronchial tissue and the occlusion of the smaller air-passages goes on to a very marked extent. In like manner the lymphangitis may spread far and wide.

If we start then with these nodular inflammatory patches it is not hard to gain an understanding of the many diverse forms in which pulmonary tuberculosis presents itself. They are all referable to this primary type, and their differences are due partly to varieties in the original bronchopneumonic patches themselves, partly to variations in the morbid phenomena which accompany their development.

As regards the bronchopneumonic patches, varieties occur chiefly in the character of the inflammatory exudation, to some extent also in the way in which the inflammation terminates—the issue of the inflammation.

In one case we may have a cellular or a fibrous exudation which rapidly becomes caseous or purulent, in another the process tends to fibrous overgrowth with partial caseation: thus we may distinguish caseous, caseo-purulent, caseo-fibroid, and fibroid or indurative varieties of tuberculous bronchopneumonia.

When the development of the nodular patches is accompanied by more extensive inflammation of the adjacent tissue, the nodular patch becomes a lobular one: thus we have a simply nodular and also a lobular form of tuberculous bronchopneumonia.

Both the primary and the secondary tuberculous patches may cease to extend and at length heal. It is very doubtful whether complete recovery of the affected tissue by re-absorption of the exudation is in any case possible, and indeed it can only occur in the very smallest patches whose vessels are not yet obliterated. In larger patches healing can only take place when the inflammatory process issues in fibrous hyperplasia and induration. The indurated portions of the lung are sometimes nodular, sometimes diffuse and extensive: they consist of slaty-grey (*induration*

ardoise) or white fibrous tissue. They may contain no caseous residues; but usually some exist scattered through the tissue, and are derived either from bronchopneumonic patches or from altered bronchial secretion. In these nodules and patches it appears likely that bacilli may persist for a considerable time, though we may take it for granted that they ultimately perish. Sooner or later the caseous residues become calcified.

In this way, so long as the affected patches are few, tuberculous disease of the lung may be entirely recovered from, or at least stayed from further advance, so that for years no new portion of the lung is invaded. Of course so long as any bacilli remain in the tissue, we can hardly speak of the recovery as complete. When a large number of tuberculous foci exist in the lung, in some of them absolute or relative recovery may take place, but it is extremely unlikely that this will occur in all simultaneously. So long however as a single patch undergoes disintegration and forms a nidus for the multiplication of the bacilli, the danger and the probability remain that the process may start afresh by extension through the lymphatics, the blood-vessels, or the air-passages.

The term tuberculous bronchopneumonia (including the associated morbid changes) is to a great extent coextensive with the clinical term **pulmonary phthisis**. The two ideas are however not identical. The lung may be destroyed by inflammations which have nothing to do either with tuberculosis or with any other of the infective granulomata. Inasmuch as phthisis primarily connotes simply destruction of tissue, it might very well be taken to include all destructive inflammations of the lung.

It is usual however to limit the term to those destructive inflammations which are progressive, that is to say which advance either steadily or intermittently from bad to worse, and that independently of fresh injury from without. This limitation then excludes those affections of the lung wherein an acute inflammation is followed by a partial destruction of tissue, which however has no tendency to extend or become general.

Even then the terms phthisis and tuberculosis are not equivalent. For as we have seen certain non-specific inflammations may take on a progressive character, and of the specific granulomatous infections glanders, syphilis, and actinomycosis lead to affections of the lung analogous to tuberculous disease.

The varieties observed in the course of tuberculous bronchopneumonia, in other words the diversities in the nature of the individual foci of inflammation, depend partly on differences in the reaction of the pulmonary tissue to irritation in different persons, but chiefly no doubt on the character and quantity of the irritant disseminated through the lung. And though our view at present is that the essential and specific irritant in tuberculous phthisis is the tubercle-bacillus, yet it can hardly be gainsaid that in many cases other injurious agencies co-operate with it.

Many pulmonary cavities or vomicae contain not only tubercle-bacilli but also other bacilli and micrococci, and these too may have a destructive action, modifying and perhaps now and then intensifying the action of the specific virus. It is possible that the caseo-purulent form of phthisis may be due to a complex infection of this nature.

With regard to recovery from pulmonary tuberculosis, many cases have been recorded; but until the discovery of the tubercle-bacillus it was impossible to decide with absolute certainty whether when a cicatrix was found in the lung the antecedent affection had or had not been tuberculous. The process of healing referred to in the text undoubtedly occurs: we would

refer in support of this not only to cases in which a clinical diagnosis of tuberculosis had been made, and years afterwards the indurative changes above described have been discovered in the lung, but also to a recently-published observation of NAUWERCK'S (*Deut. med. Woch.* 23, 1883). In the body of a man of 45, who five years before his death had for a time shown symptoms of bilateral disease of the apices of the lungs, and who died after a short illness of gastric cancer, NAUWERCK found in the apices cicatricial patches enclosing scattered caseous foci with a few tubercle-bacilli. There was no trace of recent tuberculous bronchopneumonia or lymphangitis. In the indurated fibrous tissue no bacilli were found. It is worth noting that four brothers of the patient had previously died of tuberculosis.

615. The simplest and commonest form of pulmonary tuberculosis is **nodular tuberculous bronchopneumonia**, characterised by the formation of bronchopneumonic nodules and nodes.

To give rise to it there must somewhere exist a mass of softening tubercle, a tuberculous bronchitis, or a bronchiectatic cavity: in other words a focus from which tubercle-bacilli may reach the bronchial passages and thence pass into the terminal bronchioles (Fig. 239 *b*).

If the dissemination is rapid and extend over the greater part of the lung the patient may sink very speedily, and after death the lung is found studded with miliary grey and white nodules exactly resembling embolic tubercles. This form we might describe as miliary tuberculous bronchopneumonia (Fig 237). The small patches lie partly in the alveolar ducts (Fig. 239 *c*), partly in the respiratory bronchioles (*b*): when recent they are cellular, but afterwards they become caseous or fibrous. The vessels perish as the nodules develope.

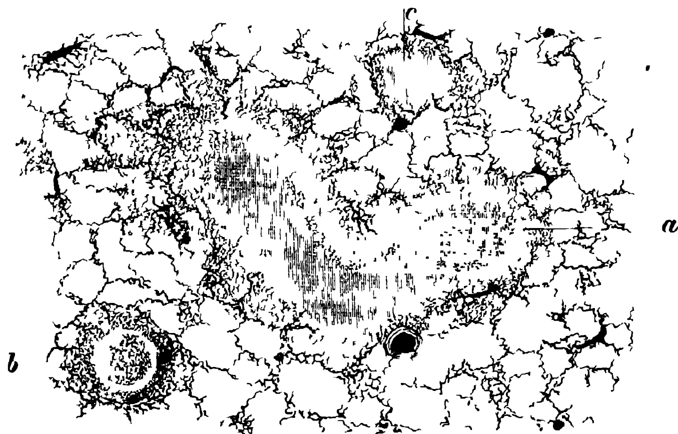


FIG. 239. NODULAR TUBERCULOUS BRONCHOPNEUMONIA.

(Preparation injected with blue, and stained with carmine: × 25)

a v-shaped patch, caseous in the centre and fibro-cellular at the periphery, produced by the infiltration of two contiguous alveolar ducts and their alveoli

b respiratory bronchiole with cellular exudation in and around it

c alveolar duct, with caseous cellular contents and infiltrated alveoli

When the virus is more gradually disseminated, so that the patient survives for a longer time, the patches become more numerous and increase in size. As a rule they become caseous in the centre (*a*) and fibrous or fibro-cellular at the periphery. The course of the disease is usually chronic, and it might therefore be described as **chronic nodular indurative bronchopneumonia.** The groups of grey or greyish-white nodules are arranged in clusters, and in section appear rounded, oval, bifurcated, or trifoliate. This is of course due to the fact that the solid nodular masses represent the terminal branches of a respiratory bronchiole. In the neighbourhood of the nodules there are always a number of obstructed bronchioles with thickened walls, looking on section like encapsuled caseous nodes.

At first the bronchopneumonic patches lie bedded in normal air-containing tissue; but after a time the surrounding tissue is usually condensed, indurated, and grey. This is due in the first place to collapse from occlusion of the bronchioles and small bronchi, and secondly to extension from the nodular patches of the inflammatory infiltration and induration, by which the alveolar walls are thickened and the alveoli are filled up with cells and ultimately fibrous tissue. The pigmentation is referable partly to inhaled dust, partly to the small haemorrhages which occur from disturbances of circulation in the diseased area or from rupture of the degenerate vessels that run through it.

The rarer form of nodular tuberculosis, **nodular caseous bronchopneumonia**, is characterised by the formation of small cellular foci, grey or yellowish-white, and rapidly becoming caseous or purulent. The caseous non-vascular nodules are always surrounded by a zone within which the alveoli are filled with leucocytes, desquamated epithelium, liquid exudation, and often fibrin, while the lung-tissue itself is infiltrated with small cells. These nodules readily soften and break down, so that little cavities are formed which sooner or later open into the adjacent bronchi.

The caseous, indurative, and caseo-fibroid forms of bronchopneumonia are met with in combination.

616. The processes just described start as a rule in the **apices of the lungs**, and thence extend downwards and backwards. The apex of a lung may thus exhibit terminal stages of the disease while the bases are still in process of invasion. After a time the parts most affected, in the caseo-fibroid or indurative form of bronchopneumonia, become almost absolutely airless, and hard and knotty to the touch. The pulmonary pleura is usually much thickened and adherent to the costal layer (Fig. 240 *a*), the lung-tissue is condensed and studded with caseous nodes (*bc*) surrounded either by translucent grey or white or by slaty-grey pigmented fibrous tissue. These nodules are occluded and indurated alveolar ducts with their alveoli (*b*), or bronchioles with caseous contents

(c) and thickened walls surrounded by condensed tissue. Between the nodules lie white or pigmented fibrous bands (e) corresponding

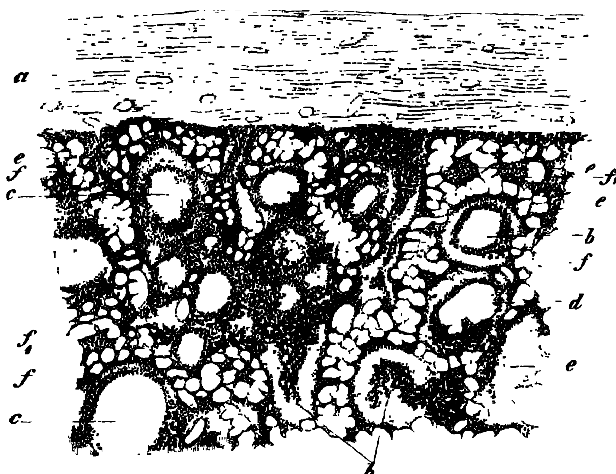


FIG. 240. CHRONIC NODOSE TUBERCULOUS CIRRHOSIS.
(*Hardened in alcohol, stained with haematoxylin:* × 20)

a thickened and fibroid pleura
b caseo-fibrous bronchopneumonic nodes
c bronchioles with caseous contents and thickened walls
d small bronchiectatic cavities
e thickened interlobular septa
f recent cellular infiltration surrounding the nodules and (f_1) the lymphatics

The alveolar septa are in parts infiltrated with cells, and the thickened and indurated tissue is pigmented

to thickened interlobular septa or peribronchial connective tissue, and grey nodules representing recent foci of inflammatory infiltration (ff_1).

The fibrous nodes and bands are coarsely-fibrous with few cells, *or mainly cellular.* Some of the nodes are caseous in the centre, *giant cells being often found in the zone between the caseous matter and the non-necrosed tissue. By appropriate treatment a few scattered bacilli can be demonstrated.* Sometimes these *indurated patches also contain typical tubercles.* The septa of the remaining portions of the lung are frequently infiltrated with cells and more or less thickened.

This morbid change may extend over the greater part of the lung, and then leads to a form of contraction and induration which we may fitly describe as **nodose tuberculous cirrhosis**. Usually however it is confined to a limited portion of the lung, other changes being set up which lead to a different result.

Even in cases where the cirrhosis is at first the characteristic feature ulceration is never entirely absent. The process may

start in the caseous foci within the lung-tissue itself, or in the bronchiectatic cavities which arise in the shrunken and airless parts. Once the process of disintegration has begun it usually advances steadily and somewhat rapidly to the formation of vomicae or caverns. Even when these cavities become lined with a layer of granulations the process is seldom thereby brought to a complete standstill, for the bacilli settled in the wall of the cavity give rise to fresh inflammatory change and fresh necrosis.

The usual course of the disease, in indurative tuberculous bronchopneumonia as in other forms, leads to the formation of cavities of considerable size, increasing not only by continuous extension but also by coalescence with others. In the latter case we may have a whole series of intercommunicating cavities, or a single large and very irregular cavern traversed and partially subdivided by bands and fragments of tissue.

The greater part or the whole of the upper lobe and parts of the lower lobe may be thus destroyed, the cavity being in places bounded only by the thickened pleura, while the collapsed and indurated pulmonary tissue is much reduced in bulk. The cavity contains air, and greyish, yellowish, or brownish liquid, mingled with pus-cells and whitish shreds and fragments of necrotic lung-tissue usually beset with bacilli. The disintegration of the lung-tissue takes place much more rapidly in caseous and caseo-purulent bronchopneumonia than in the indurative form. It sometimes happens that in a very short time from the onset of the malady the whole lung is riddled with cavities, whose caseous and infiltrated walls break down into shreds as if they were rotten. When such a cavity lies immediately underneath the pleura there is always (unless previous adhesions limit the process) a certain amount of fibrinous or purulent inflammation of that membrane. Not infrequently the pleura is perforated and **pneumothorax** or **pyopneumothorax** is set up.

The caseo-fibroid, caseous, and caseo-purulent forms of bronchopneumonia occur in various combinations and give rise to a great variety of different morbid appearances in different cases. Sometimes a suppurative form of the inflammation is grafted on a chronic caseo-fibroid form, and leads to a marked acceleration of the destructive process.

The striking fact that tuberculous bronchopneumonia usually begins in the apex of the lung points to the conclusion that the settlement and multiplication of the tubercle-bacilli take place more readily there than in other parts. In the apex the respiratory movement is relatively smaller, and the amount of blood in circulation less. Any bacilli which may reach the apex by aspiration are therefore less readily carried off by the lymphatics and destroyed by the living tissue-cells: in other words the tissue is there less resistent. A fact perhaps still more significant is this—that residues of previous inflammation (Art. 611) linger longer in the apex than elsewhere in the lung, and in this way cause a kind of local weakness or predisposition to bacillary invasion in that part.

617. **Lobular caseous tuberculous bronchopneumonia** always starts in miliary or nodose bronchopneumonia. Sometimes in the neighbourhood of recent cellular or partially caseous broncho-

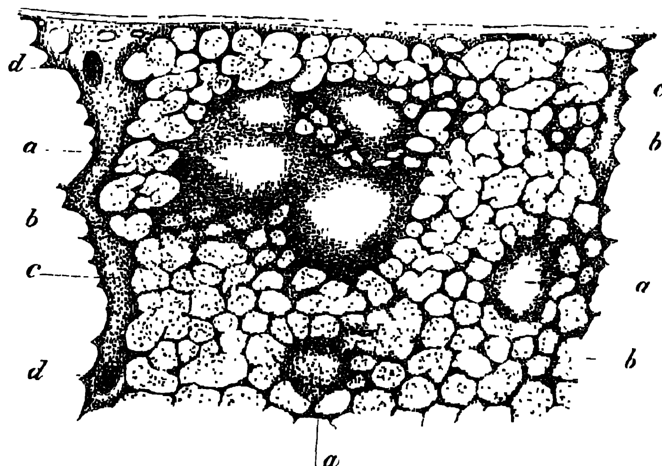


FIG. 241. LOBULAR CASEOUS TUBERCULOUS BRONCHOPNEUMONIA.

(*Section through a subpleural lobule; hardened in alcohol, stained with haematoxylin:* × 25)

a nodule with caseous centre and cellular periphery
b alveoli filled with exudation, the walls infiltrated with leucocytes
c interlobular septa infiltrated with leucocytes
d lymphatics filled with exudation

pneumonic foci (Fig. 241 *a*) a lobular inflammation is set up, which is marked by cellular infiltration of the alveolar (*b*) and interlobular (*c*) septa, and distension of the alveoli and lymphatics (*d*) with a fibrinous liquid and cells. The tissue thus infiltrated sooner or later becomes caseous and breaks down, induration seldom occurring to any appreciable extent.

At first the inflamed lobules appear on section airless, greyish-red, smooth, gelatinous, and infiltrated: the condition has been well described as **gelatinous infiltration**. They afterwards become paler, then grey and translucent, and lastly opaque yellowish-white.

The number of the lobules so affected is of course variable. When they are numerous we usually find at the time of death that different lobules are in different stages of the process, some being greyish-red, others grey, others yellowish-white. Frequently the latter show signs of softening and excavation, or there are actually cavities of considerable size and communicating with the air by way of the bronchi.

When all the lobules of a lobe are thus affected, the disease assumes the appearance of a lobar affection and is often so described (Art. 606). Microscopical examination however always proves

that some of the lobules have been affected long before the others, and so does away with the idea of a 'lobar caseous pneumonia.'

The pleura over the affected lobules is always inflamed, and usually covered with fibrinous exudation. As the lobules break down the pleura may suppurate and become caseous, and so break down in like manner.

When lobular caseous bronchopneumonia is found in a lung we always find also older morbid changes in it, usually at the apex but at times in other parts. They may be slight, consisting of a few scattered points of caseation, or some indurated nodules, or dilated bronchi. In other cases the lobular caseation is but a terminal complication of an advanced nodose, caseous, or indurative bronchopneumonia. The lobular process may in fact be combined in a multitude of ways with the nodose.

Lobular caseous bronchopneumonia is most frequent in children, though it is by no means rare in adults. By many pathologists it is referred to as **scrofulous pneumonia.**

618. **Bronchopneumonia from actinomycosis, glanders, and syphilis.** The pulmonary affection set up by *Actinomyces* (Art. 134) takes the form of a bronchopneumonia, the diseased patches being of miliary size or larger. In cattle the patches are hard and nodular, and contain in the centre the ray-fungus as a kind of nucleus (PFLUG, HINK). In man the affection tends to be suppurative (ISRAEL, PONFICK), yellow or greyish-yellow patches being formed which presently by softening and suppuration give rise to corresponding cavities. These may become larger and larger, and at length break through the pleura. The characteristic feature of the process is of course the presence of the ray-fungus in the pus and in the infiltrated and disintegrated lung-tissue.

When glanders-bacilli (LOFFLER and SCHUTZ, *Deut. med. Woch.* 52, 1882; CORNIL and BABES, *Les bactéries* Paris 1885) reach the lung by aspiration, they give rise to the formation of nodules and nodes chiefly beneath the pleura. At first they are soft and greyish, afterwards they become firmer and in part caseous. Patches of lobular extent and greyish-red in tint, and patches of bronchopneumonic suppuration, are also met with in glanders, and there may be a certain amount of haemorrhagic inflammation. When the disease affects a number of contiguous lobules, large portions of the lung may in this way be infiltrated and ultimately break down. When the bacilli reach the lung through the circulation they induce pneumonia, which resembles in many respects the bronchopneumonic forms just referred to.

Syphilis first of all gives rise to bronchitis, which in course of time leads to peribronchial induration, with occlusion and dilatation of bronchi (Arts. 578—579). According to some catarrhal, indurative, suppurative, and caseous forms of bronchopneumonia may also result from syphilis. The caseous forms are said to include both lobular and nodular varieties.

References on pulmonary actinomycosis :—ISRAEL, *Virch. Arch.* vols. 74, 78, and *Beitr. z. Kenntn. d. Actin. d. Menschen* Berlin 1885; PONFICK, *Die Actinomycose des Menschen* Berlin 1882; PFLUG, *Cent. f. med. Wiss.* 14, 1882; HINK, *ibid.* 46, 1882; MARCHAND, Article *Aktinomykose*, *Eulenburg's Real-encyclop.*

On pulmonary glanders see BOLLINGER, *Zeitschr. f. Thiermed.* 1876, *Ziemssen's Cyclop.* III; WERNER, *Der Lungenrotz* 1878; RABE, *Jahresber. d. Thierarzneischule* Hanover 1876; PUTZ, *Seuchen u. Herdekrankheiten* Stuttgart 1882; DIECKERHOFF, *Lehrb. d. spec. Path. f. Thierärzte* I Berlin 1885.

On pulmonary syphilis see Art. 518.

CHAPTER LXXXVIII.

TUMOURS AND PARASITES OF THE LUNGS.

619. **Primary tumours** of the lung or bronchi are rare. Primary **carcinoma** may occur in the larger bronchi as irregular nodose or papillary growths, starting either in the mucous glands or in the lining epithelium. Similar growths are also met with in the smaller bronchi, and these tend to spread over large portions of the bronchial ramifications. The disease may then extend to the peribronchial lymphatics, whereupon its generalisation takes place with great rapidity, the air-passages both of the part originally affected and of remoter parts becoming studded with white marrowy nodes and nodules. The disease ultimately attacks the interlobular lymphatics and the lymphatic glands. In a third form of carcinoma large solitary nodes appear, of which we cannot say whether they start in the bronchioles or in the alveoli. They enlarge by the continual invasion and filling up of the alveoli at their borders with the cancerous epithelial growth. They also may invade the lymphatics and then extend in the same way as the second form. CHIARI has described a nodular **adenoma** of the mucous glands in the bronchial mucous membrane.

ROKITANSKY, MORGAN, RINDFLEISCH, and others have described cases of **fibroma**, in which nodules from the size of a hemp-seed to that of a hazel-nut were formed in large numbers around the bronchi. **Osteoma** also occurs in the form of irregularly-shaped structures with jagged processes, and of rounded nodules of the size of a pea; small globular chondrolipomata (ROKITANSKY, CHIARI), and **enchondromata** starting from the bronchial cartilages, have also been met with.

Of **secondary growths** examples of each kind that forms metastases at all have been found in the lungs. When the tumour-cells reach the lung as emboli they usually produce rounded nodules having the characters of the parent-tumour. These start from the embolised blood-vessels, and grow by radial extension or concentric accretion, partly invading and partly compressing the pulmonary tissue. The lymphatics may likewise be invaded by the growth, which then advances by this channel.

When the tumour-cells originally reach the lung or pleura by the lymphatics, nodules of various sizes appear along the course of the latter. In the case of cancer the diffusion is often remarkably uniform, so that the lymphatics of a large portion or the whole of the lung are distended with white marrow-like masses. On section such a lung exhibits a number of close-set whitish or reddish nodes along the course of the bronchi or interlobular septa.

The neoplastic growth often sets up inflammations especially of the pleura, and these not infrequently are haemorrhagic in character.

Primary carcinoma of the lung:—ROKITANSKY, *Path. Anat.* IV; EBERTH, *Virch. Arch.* vol. 49; LANGHANS, *ibid.* vol. 53; PERLS, *ibid.* vol. 56; WEICHSELBAUM, *ibid.* vol. 85; SCHOTTELIUS, *Ein Fall v. prim. Lungenkrebs* In. Diss. Würzburg 1875; FENLEY and PARKER, *Med. chir. Trans.* LX (1877); STILLING, *Virch. Arch.* vol. 83; REINHARDT, *Arch. d. Heilk.* IX (1878); CHIARI, *Prag. med. Woch.* 1883; BECK, *Zeitschr. f. Heilk.* V 1884.

Connective-tissue tumours of the lung:—ROKITANSKY, *Path. Anat.* IV; MORGAN, *Trans. Path. Soc.* 1871; VIRCHOW, *Krankh. Geschwülste* II; FORSTER, *Virch. Arch.* vol. 13; RINDFLEISCH, *ibid.* vol. 81; HESSE and E. WAGNER, *Arch. d. Heilk.* XIX; HARTING and HESSE, *Eulenburg's Vierteljahrsschr.* XXX, XXXI; CHIARI, *loc. cit.*; RIBBERT, *Virch. Arch.* vol. 102 (lymphoma); COHN, *ibid.* vol. 101 (osteoma).

HESSE and WAGNER state that the Schneeberg miners frequently suffer from peculiar tumours in the lung, which WAGNER describes as lymphosarcomata. COHNHEIM (*Allgem. Pathol.* I) suspects that they are due to some form of infective granuloma.

620. The **animal parasites** infesting the bronchi and the lungs are not numerous. The most important is *Echinococcus*, which may form hydatid cysts of considerable size, with or without daughter-cysts. *Cysticercus cellulosae* is rare. *Strongylus longevaginatus*, a cylindrical worm 15—26 mm. long, has once been found in a boy's lung, and ORTH discovered a calcified *Pentastoma denticulatum* (Art. 225). KANNENBERG has in several cases of gangrene of the lung discovered *Monas lens* and *Cercomonas* (Art. 250), two flagellate infusorians, among the shreds of lung-tissue in the sputa. In the resting state they look not unlike white blood-corpuscles.

Of **vegetable parasites** in the lungs the most noteworthy are the numerous varieties of bacteria. Some of these, such as the bacilli of tuberculosis and of glanders, and the micrococcus of pneumonia, give rise to specific inflammations. Others again, such as those which inhabit the mouth, may possibly give rise to non-specific inflammations of various intensity when aspirated into the air-passages.

Gangrenous portions of the lung contain micrococci, bacilli, and spirilla. Some of these have probably much to do with the gangrenous decomposition, others probably settle only in the already disintegrated tissue.

In tuberculous cavities, disintegrating haemorrhagic patches,

croupous exudations within the bronchi and trachea, etc. we occasionally meet with a micrococcus which subdivides like *Sarcina* into tetrads, and has accordingly been regarded as a minute variety of that species (HEIMER). It usually occurs at the same time also in the pharynx and larynx, and has probably no causal connexion with the respective diseases in question. It is however not impossible that it may have the power of setting up inflammation where it settles.

Of the filamentous fungi or hyphomycetes we find in the lung the bovine *Actinomyces*, and various forms of *Aspergillus* and *Mucor*. The former is the only one that possesses any great pathological importance: the others, with *Oidium*, settle only in decomposing lung-tissue, stagnating secretions, or haemorrhagic infiltrations. The above-named mould-fungi now and then proceed to the stage of fructification within the lung.

References on fungi in the lung or **pneumonomycosis** :—VIRCHOW, *Froriep's Notizen* 1846, *Virch. Arch.* vols. 9, 10; FRIEDREICH, *ibid.* vol. 30; COHNHEIM, *ibid.* vol. 33; BRISTOWE, *Trans. Path. Soc.* 1854; MUNK, *Cent. f. med. Wiss.* 1864; HEIMER, *Ueber Pneumonomycosis sarcinica* In. Diss Munich 1877; NAUWERCK, *Corresp. f. Schweiz. Aerzte* XI (1881); FRIEDREICH, VON DUSCH, and PAGENSTECHER, *Virch. Arch.* vols. 10, 11; P. FURBRINGER, *ibid.* vol. 66; ROSENSTEIN, *Berl. klin. Woch.* 1867; LICHTHEIM, *ibid.* 1882; BOLLINGER, *Zur Aetiol. d. Infectionskrankheiten* Munich 1881; AUFRECHT, *Path. Mittheil.* II 1883; KANNENBERG, *Virch. Arch.* vol. 75, *Zeitschr. f. klin. Med.* I 1880.

According to BAELZ (*Cent. f. med. Wiss.* 39, 1880) a peculiar parasitic disease of the lung (*gregarinosis pulmonum*) is very common in Japan. Patients affected with it spit blood for a number of years, and their lungs contain encysted brownish-yellow ovoid *Psorospermia* and clear or pale-yellow non-encysted granular round or ovoid *Coccidia* (Art. 250). The affection is also met with in Formosa, and according to MANSON is due to the presence in the lung of *Distoma ringeri*, of which BAELZ'S *Psorospermia* are said to be merely the ova (*Med. Times and Gaz.* 2, 1881 and 2, 1882, *Brit. Med. Journ.* 2, 1882).

CHAPTER LXXXIX.

THE THYROID GLAND.

621. The **thyroid gland** is developed from a vesicular diverticulum of the throat-cavity, which afterwards becomes detached; its epithelium proliferates and grows into the surrounding fibrous tissue as cords and masses of cells, which form the primitive gland-tubes and follicles. Cavernous blood-vessels penetrate among these cell-masses and divide up the rudimentary gland into groups of cells of various sizes. These vessels are then differentiated into arteries, capillaries, and veins of ordinary dimensions, in the meshes of which the mature glandular structures make their appearance. These consist of rounded masses and cords of cells, forming follicles which at or soon after birth exhibit a central lumen distended with secretion or containing a little granular detritus. The cells surrounding the lumen are cubical or cylindrical and are seated directly on the blood-vessels. Between the follicles lie a number of what we may call unutilised epithelial cells; in the later stages of growth these may be fashioned into new follicles. Papillary overgrowth of the epithelium may also lead to the subdivision of an old follicle into two or more new ones.

In the fully-developed gland we can distinguish a cortical and a medullary substance: the latter contains radially disposed follicles and gland-tubes, the former masses and cords of cells concentrically arranged. In later life some of the glandular follicles contain colloid matter (Fig. 242 *c*).

In old age the substance of the gland undergoes more or less marked atrophy, the follicles shrinking to clusters of small cells or disappearing altogether, and the fibrous stroma becoming homogeneous and indurated, and at the same time increased in relative amount.

The adult thyroid consists of two lateral lobes and an isthmus uniting the two across the front of the trachea. The vertical diameter of a lateral lobe is 5—7 cm., the breadth 3—4 cm.; the width of the isthmus varies from 4 to 20 mm. Very frequently there is a middle lobe or pyramid, which rises from the isthmus and grows upward.

Absence of the thyroid is rare. More common **anomalies** are—abnormal smallness or absence of a lobe or of the isthmus, abnormal largeness, multiple lobes, and accessory glandular masses separate from the main mass and connected with the hyoid, the deeper parts of the trachea, the supraclavicular fossae, the interior of the larynx (P. BRUNS), the aorta, or the posterior wall of the pharynx. In very rare instances the isthmus is found to pass between the trachea and the oesophagus.

The most important of the morbid changes to which the thyroid is liable are those forms of enlargement of the whole gland or of particular parts of it included under the general term **goitre**, bronchocele or thyreocele (*struma*).

The gland may be enlarged from birth and constitute a **congenital goitre**. The enlargement may be due to over-distension or telangiectatic dilatation of the vessels, to hypertrophy of the gland-tissue, to premature and excessive colloid deposit, to increase of the fibrous stroma, or to adenomatous growth. The hyperaemic enlargement is of course transient, but the other varieties persist.

In later life also the thyroid may be enlarged by hyperaemic distension, constituting **vascular goitre**. The condition is not usually lasting, though it may become chronic.

A second form named **hypertrophic goitre** is due to multiplication and enlargement of the normal cell-masses (Fig. 242 *a*) and follicles (*b*), or to increase of the normal colloid contents (*c*). In the first case we have parenchymatous or follicular or **glandular** goitre, in the second case colloid or **gelatinous** goitre.

The new follicles arise (WOLFLER) from unutilised glandular cells, either by direct multiplication and grouping into orderly masses, or by endogenous multiplication of individual cells. The

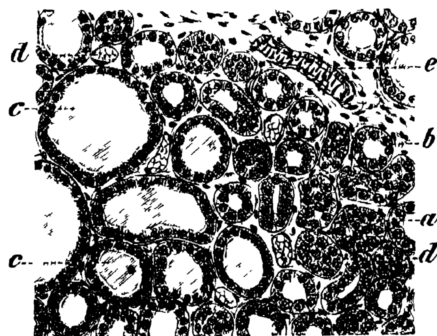


FIG. 242. GOITRE PARTLY HYPERTROPHIC AND PARTLY COLLOID.

(*Alum-haematoxylin staining*: × 60)

a follicles filled with cells
b empty follicle
c colloid masses
d capillaries
e stroma with arteriole

new follicles are separated from each other by fibrous tissue and blood-vessels. Pure hypertrophy of the thyroid is however not very common. It may be general or localised, and may exist from birth.

Adenoma of the thyroid is an epithelial new growth occurring in the form of isolated nodules, or diffused over one or both lobes. It consists of vascular non-typical gland-like tissue, which persists in this form or is transformed more into the likeness of the normal gland-tissue. WOLFLER distinguishes four varieties—the foetal, the gelatinous, the myxomatous, and the columnar-celled. These adenomata occasionally recur after excision, and are not easily distinguished from carcinomata.

Foetal adenoma arises from some rudiment of embryonic tissue, though its growth may not be apparent till puberty or pregnancy: it occurs in nodes from the size of a pin's head to that of the fist. Its tint is pale-yellow, dark-red, or brownish-black, according as it is less or more vascular.

The nodes grow in much the same way as the gland originally developes; the smallest nodules accordingly consist of proliferous masses of round or oval not very sharply-defined cells, interspersed with dilated and varicose vessels. By degrees these vessels are differentiated into narrow capillaries and wider trunks, and then again assume gradually the typical configuration of the vascular system of the gland, while the proliferous epithelial cells become arranged in groups and follicles.

The nodes do not however reach this degree of development, but remain in various intermediate stages.

Adenomata, both small and large, which are traversed by numerous cavernous vessels, and so have a dark-red tint, are very liable to internal haemorrhages. The glandular follicles within an area of extravasation not infrequently dilate into ramifying channels, which by and by are constricted off into vesicular cavities. Large extravasations are sometimes transformed into hyaline masses which afterwards become vascularised and traversed by bands and cords of proliferous glandular cells. In other instances scar-like or homogeneous cicatricial tissue is formed, and contains here and there dilated blood-vessels.

Gelatinous adenoma is a tumour, nodulated, tuberous, or smooth, occupying the whole gland or a single lobe, and on section appearing of a fairly uniform jelly-like consistence. The scanty stroma of the gland is in fact pervaded and distended by variously-sized lumps of colloid substance.

The growth starts in the glandular cells which lie between the true follicles. As these cells multiply they give rise to new follicles or acini which secrete the colloid matter. These growths indeed are related on the one hand to the simple hypertrophies, on the other to medullary carcinoma. WÖLFLER distinguishes two varieties of gelatinous adenoma—interacinous adenoma, and cyst-

adenoma. **Interacinous** adenoma, as it may briefly be called, is the commonest form of goitre and the largest. It consists essentially of gland-like vesicles or cysts filled with colloid substance and lined with cubical or spherical epithelial cells. Between the fully-formed vesicles lie rudimental cell-masses and follicles in process of development. The epithelial cells of the older vesicles may multiply to such an extent as to fill them up (*adenoma interacinosum proliferans*). Interacinous adenoma may co-exist with the foetal form. **Cystadenoma** is characterised by the formation of cysts varying in size from that of a lentil to that of a goose's egg. The proliferous cells which these cysts contain undergo fatty and colloid degeneration. The intercystic vessels and fibrous tissue become atrophied. In some parts the interacinous cell-groups grow and break into the cysts, and there undergo colloid change: or they may simply push the cyst-epithelium before them, and the papillary ingrowths thus formed tend to become covered with cylindrical cells. New cysts are sometimes formed in the substance of these ingrowths, and thus the original cysts may become filled with minor cysts. Nodes containing cysts and ingrowths of this kind are described as proliferous cystadenomata, and occasionally lead to the formation of enormous goitres in which the whole of the thyroid is included. In the human subject however they are not common: in the monkey and the dog these formations occur in the normal gland. The neoplasm is usually most characteristically developed in the central parts of the goitre; the periphery consists mainly of non-excavated follicles and cell-masses. The intercystic stroma is frequently fibromyxomatous, or consists of hyaline tissue resulting from haemorrhagic infiltration. The colloid substance is formed only in small quantity by the cylindrical epithelium of the papillary ingrowths. Sometimes the glandular follicles and vesicles become calcified, their epithelium undergoing fatty degeneration.

Myxomatous adenoma (follicular and tubular) occurs both in young and in old patients: it takes the form of soft nodose growths of various sizes and often highly vascular. The neoplasm consists of a hyaline structureless or faintly striated matrix, occasionally in part calcified, interspersed with solid globular cell-masses, follicles, and cords of cells of various forms. Normal follicles are as a rule conspicuously absent.

The myxomatous condition is secondary, being a transformation of a foetal or interacinous adenoma. The transformation is due to haemorrhagic infiltrations of the tumour-tissue such as are known to occur at puberty, during the catamenia, and during pregnancy. The infiltrated area assumes a hyaline appearance, or if it is partially vascularised it becomes more fibrous and ultimately fatty and calcareous: if the vascularisation is more complete the glandular cells multiply and the growth is pervaded with new-formed cell-masses and tubules.

Columnar-celled adenoma is characterised by the presence in

it of vesicles or acini lined with tall columnar epithelium, and traversed by irregular solid cords and bands made up of the same kind of cells. The new growth is distinguished from mere hypertrophy of the follicles that are lined with columnar epithelium in the normal gland by the presence of glandular tubules of the embryonic type. According to WÖLFLER this form is very rare.

Goitre is dangerous to the patient afflicted with it chiefly from the pressure it may exert on the trachea, the oesophagus, or the large vessels of the neck. The trachea is compressed when the goitre grows down beneath the sternum, or when it reaches a very large size and surrounds the trachea and oesophagus or pushes them to one side. The continuous pressure sometimes causes atrophy of the tracheal cartilages, and the tumour then protrudes into the air-passage. Accessory thyroid glands may become goitrous like the principal mass.

References :—ECKER, *Zeitschr. f. rat. med.* VI 1847; LEBERT, *Die Krankh. d. Schilddrüse* Breslau 1862; FRIEDREICH, *Virchow's Handb. d. spec. Path.* V 1858; ROKITANSKY, *Anat. d. Kropfes* Vienna 1849; DAVIES, *Trans. Path. Soc.* 1849; VIRCHOW, *Krankh. Geschwulste* III; LUCKE, *Pitha u. Billroth's Handb. d. Chir.* III 1875; DEMME, *Gerhardt's Handb. d. Kinderkr.* III; STROMEYER, *Arch. f. phys. Heilk.* IX (1850); GUILLOT, *Arch. générales* 1860; PARSONS, *Med. Times and Gaz.* 2, 1862; KONIG, *Arch. f. Heilk.* 1865; GEUZMER, *Virch. Arch.* vol. 74; LUCKE, *D. Zeitschr. f. Chir.* VII; KAUFMANN, *ibid.* XVIII; W. MULLER, *Jena. Zeitschr. f. Med.* VI 1871; COHNHEIM, *Virch. Arch.* vol. 68; BUOB, *Du goître congén.* Strasburg 1867; HECKER, *Monatsschr. f. Geburtskunde* XXXI 1868; SPIEGELBERG, *Würzburg. med. Zeitschr.* 1864; NIÈPCE, *Traité du goître* Paris 1851; LUTON, Art. *Goître, Nouv. dict. de méd.* XVI 1872; BERGER, *Arch. de méd.* 1874; HILDEBRAND, Art. *Struma, Eulenburg's Real-encyclop.*; WÖLFLER, *Ueb. d. Entwickelung u. d. Bau d. Schilddrüse* Vienna 1880 and *Entwick. und Bau d. Kropfes, Langenbeck's Arch.* XXIX 1883; MADELUNG (accessory thyroids) *ibid.* XXIV; LEITZ, *ibid.* XXIX; GORE, *Fortschr. d. Med.* I 1883; GUTKNECHT, *Virch. Arch.* vol. 99; STRECKEISEN, *ibid.* vol. 103.

The account in the text is based chiefly on the recent admirable researches of WÖLFLER: without agreeing with him in all details we think his work the best that has yet appeared on the structure and genesis of goitre.

622. The adenomata described in the last Article do not in general extend beyond the limits of the thyroid gland, and are therefore to be classed with the innocent or non-malignant growths. Varieties of proliferous cystadenoma and follicular adenoma do however occur, which are characterised by their vascularity, their highly cellular nature, and their rapid growth; and these are apt to recur after excision. Other varieties depart more or less from the adenomatous type, approaching that of carcinoma, and these may form metastases.

These transitional varieties are best described as **malignant adenomata** (WÖLFLER). They have in parts a greyish-white medullary or encephaloid appearance, and contain amid structures unmistakeably adenomatous patches exactly resembling carcinomatous tissue. This is the case even when the metastatic growths have a structure almost exactly corresponding to that of the

normal thyroid gland. In considering the statement of COHNHEIM and HESCHL—that normal thyroid hypertrophies and apparently innocent adenomata may give rise to metastases—we must therefore bear in mind also that malignant adenoma and carcinoma are occasionally accompanied by metastatic growths whose structure closely resembles that of non-malignant adenomatous tissue. Even in the parent-tumour in the latter case we at times find structures very similar to normal thyroid acini with a lumen and a regular epithelial lining.

Carcinoma of the thyroid occurs in regions where goitre is endemic, and usually developes in an existing goitrous growth. As a rule it is soft and medullary, forming nodose tumours from the size of a hen's egg to that of a child's head, and seated in one of the lobes of the gland. It is usually surrounded by normal gland-tissue or adenomatous tissue. Rarely is the whole gland transformed to cancer-tissue. Secondary growths, and irruptions into the trachea or larynx, are common; but both are often absent for a long space of time, the tough cortical substance of the gland offering considerable resistance to the advancing growth.

WÖLFLER distinguishes three forms of carcinoma—alveolar, columnar-celled, and squamous-celled. **Alveolar** carcinoma is the commonest, and occurs as greyish nodes surrounded by fibrous tissue and seated in the parenchyma of the gland, or as a uniform medullary infiltration of the goitrous tissue. The proliferous epithelial cells are usually rounded or oval, or sometimes polymorphous; they form globular or elongated masses or nests separated by fibrous bands of varying thickness Between the nests we frequently find persistent remnants of normal follicles. The development of the growth begins in the epithelial cells which lie 'unutilised' or form compact masses between the gland-follicles. The lining epithelium of the follicles takes no part in the development of the cancer, which thus in its mode of growth recalls the gelatinous adenoma in which it often originates: it is indeed distinguishable from the latter only by the fact that no trace of reversion to any glandular type appears in it. The old gland-follicles often persist for a long time amid the advancing growth, but are ultimately encroached on or filled up by the new-formed cancer-cells. **Columnar-celled** carcinoma corresponds in structure to the columnar-celled parts of the normal gland and to columnar-celled adenoma. It takes the form of nodes whose cut surface is white or greyish-red. The neoplastic tissue is characterised by the presence in it of solid cords of cells, and of tubules and follicles clothed with cylindrical epithelium and containing papillary ingrowths exactly resembling those of papillary cyst-adenoma. WÖLFLER regards this form also as originating in the interacinous epithelial cells. **Squamous-celled** carcinoma is a rare form (FÖRSTER, EPPINGER, LUCKE, KAUFMANN, BRAUN). As there is normally no squamous epithelium in the thyroid it is not

improbable that, in cases where the growth does not start from the oesophagus, it is due to the morbid development of embryonic epithelial cells accidentally enclosed in the gland on the closure of the branchial clefts.

Of the **connective-tissue tumours** of the thyroid **sarcoma** is the commonest, and usually originates in an already-existing goitre. Both round-celled and spindle-celled sarcoma are described, and WÖLFLER adds to the list of forms—giant-celled sarcoma, angiosarcoma, and alveolar sarcoma. They form irregular nodulated tumours extending over a part or the whole of a single lobe, seldom over the entire gland. The cut surface is generally smooth, though the tumour is usually more or less lobulated by the bands of firm fibrous tissue which traverse it. The tint is white or greyish, pink, reddish-brown, or dark-brown, according to the amount of blood present. The latter tint prevails where there are cavernous blood-vessels with haemorrhagic infiltrations. The tumour is more or less firm according as it is fibrous or cellular: the round-celled form is the softest. The acini surrounded by neoplastic tissue often survive a long time. Tumours are described in which muscle-fibres appeared to be included. Secondary growths are set up in consequence of invasion of the lymphatics or blood-vessels. Sarcoma occurs in patients of all ages.

WÖLFLER describes a case of **fibroma** in a man of 56; it took the form of multiple hard nodes of about the size of a walnut.

Carcinoma and sarcoma of the thyroid are often included under the term malignant goitre (*struma maligna*).

References :—VIRCHOW, *op. cit.*; EBERTH, *Virch. Arch.* vol. 55; EPPINGER, *Prager Viertelj.* 1875; KOCHER, *D. Zeitschr. f. Chir.* IV; KAUFMANN, *ibid.* XI, XIV; LÜCKE, *Arch. f. klin. Chir.* VIII; ROSE, *ibid.* XXIII; W. MÜLLER, *Jena. Zeitschr. f. Med.* VI 1871; VON WINIWARTER, *Beitr. z. Statistik d. Carcinome* Stuttgart 1878; CORNIL, *Arch. de physiol.* 1875; PAYNE, *Trans. Path. Soc.* XXII 1871; DEMME, *Jahresber. d. Berner Kinderspitals* 1879 and *Gerhardt's Handb. d. Kinderkr.* III; GRIFFINI, *Arch. per le scienze med.* IV 1880; PINNER, *D. Zeitschr. f. Chir.* XVII 1882; BRAUN, *Langenbeck's Arch.* XXVIII; E. NEUMANN, *ibid.* XXIII; BIRCHER, *Sammlung klin. Vorträge* 222; HEATH, *Med. Times* 1879; HUGUENIN, *Arch. d Heilk.* XV 1874; WÖLFLER, *loc. cit.*; HAWARD, *Trans. Path. Soc.* XXXIII 1882.

623. In all forms of goitre certain retrogressive changes are apt to take place, and these to a greater or less extent alter the appearance of the growth.

Haemorrhages are common, either in the form of small ecchymoses or of large extravasations extending over the greater part of the tumour and giving it a dark-brown tint. They sometimes constitute a large portion of its bulk, and when they occur within thin-walled cysts may lead to their rupture. These extravasations also lead to wide-spread disintegration and necrosis of the tissue of the tumour, forming foci of brown or yellow softening which ultimately take the form of cysts. As we

mentioned in Art. 621 small extravasations may be followed by proliferation of the glandular parenchyma and formations of hyaline or fibrous tissue. If the fibrous overgrowth be marked indurations and cicatrices result, and these sometimes become in course of time calcified.

When the goitrous tissue disintegrates in consequence of haemorrhagic infiltration **fatty change** often sets in round about the affected area, and oil-globules mingle with the necrotic detritus and disintegrated blood-cells; when the fatty change is marked this may give the pulpy contents of the softened patch a creamy or yellowish-white colour. The tissue enclosing the patch is usually more or less inflamed, and as the detritus is gradually absorbed a cyst-wall of indurated fibrous tissue is developed.

Haemorrhage, necrosis, and fatty degeneration of this kind, together with the inflammatory changes that accompany these, are the commonest causes of the **fibroid degeneration** and induration so frequently met with in goitres. When these changes affect the central parts they give rise to large white radiating cicatrices. Where haemorrhages have been frequent a more diffuse induration is set up, which is then apt to spread over the whole tumour and cause the degeneration and atrophy of the glandular elements. The new-formed fibrous tissue is usually white and lustrous, often resembling hyaline cartilage.

Calcareous deposits occur in the gland-tissue as well as in the new-formed fibrous tissue, and are first seen in the colloid masses contained in the acini and in the interacinous tissue. In advanced cases the entire contents of the acini are transformed into shining stratified calcareous grains. In the interacinous tissue the deposit is most marked where fibrous hyperplasia has occurred, and it is consequently by no means uncommon to find the indurated parts transformed into gritty masses and the cysts of disintegration enclosed by capsules that are completely calcified. FÖRSTER and LÜCKE describe cases in which the fibrous tissue has become ossified.

A very common occurrence in goitrous tumours is the excessive development of **colloid substance**, especially when the interacinous vessels are few and narrow. The colloid substance is secreted by the epithelium in the form of clear colourless droplets, and the detached epithelial cells are themselves transformed into similar hyaline masses. When the secretion is exceptionally abundant the tumour consists almost entirely of a translucent honey-like substance lying in masses separated only by thin fibrous septa. This form is described as **gelatinous goitre** (*struma gelatinosa*). WOLFLER describes it as a parenchymatous atrophy of the gland, and regards it as an advanced stage of gelatinous adenoma: he supposes that the intra-acinous elements are transformed into colloid substance, while the interacinous tissue becomes atrophied.

So-called **multilocular cystoma** probably arises in the same way: the atrophy of the interacinous tissue and its vessels goes on almost to complete disappearance, and the follicles thus come together and coalesce.

When the secretion of colloid substance is very rapid some of the acini may burst, and their contents pass into the surrounding tissue. This tissue is thus disintegrated and destroyed, and a cyst is formed containing colloid material and frequently extravasated blood. In other cases cicatricial tissue is developed. Sometimes an over-distended acinus ruptures through the skin or into the larynx or trachea.

Amyloid degeneration takes place in thyroid glands otherwise normal, and also in goitres: it chiefly affects the blood-vessels. Local amyloid deposits are also met with in the form of lardaceous or waxy nodes (BECKMANN).

Acute **inflammation** of the normal or goitrous gland (thyroiditis, and acute strumitis) occurs as a result of traumatic injury, of septic or pyaemic infection, after typhoid, diphtheria (BRIEGER), and rheumatism; it may also arise idiopathically, and causes more or less painful swelling of the part. If suppuration takes place one or more pus-cavities or abscesses or even patches of gangrene result, and these may rupture into surrounding parts. Chronic inflammation and induration are usually due to internal necroses: other forms are very rare.

Tuberculosis of the thyroid gland is not very common, though in haematogenous miliary tuberculosis eruptions of tubercle are met with in it: larger tuberculous foci have also been described.

Gummata of the thyroid are very rarely met with.

References on **thyroiditis** and strumitis:—BECK, *Arch. f. physiol. Heilk.* 1851; BAUCHET, *Gaz. hebd.* 1857; MARTINACHE, *De l'inflam. aigue du corps thyr.* Paris 1861; CHANTREUIL, *Gaz. des hôpitaux* 1866; STAUDENMEYER, *Zeitschr. f. chir. Med. u Geburtsh* 1870; KOCHER, *D. Zeitschr. f. Chir.* X; ROELLINGER, *De la thyr. aigue* Paris 1877; BOGEHOLD, *Deut. med. Woch.* 1880; PUICHAUD, *Paris médical* 1881; WEIGERT, *Virch. Arch.* vol. 88 (tuberculosis); CHIARI, *Stricker's med. Jahrb.* 1878 (tuberculosis); VIRCHOW, *op. cit.*; DEMME, *loc. cit.*; WOLFLER, *op. cit.*; DUMOLARD, *Lyon médical* 44, 1878; BRIEGER, *Charité-Annalen* VIII 1883 (diphtheria); CORNIL and RANVIER, *Man. Path. Hist.* I London 1882 (tuberculosis); BARTH and GOMBAULT, *Progrès médical* 1884 (syphiloma).

623 *a*. The **aetiology of goitre** is at present imperfectly understood, but we know something at least of the conditions under which it usually appears. We have already seen (Art. 621) that increased flow of blood to the thyroid body, or obstruction of the flow from it, may occasion a very marked swelling of the gland. Such a swelling is not always transient, but sometimes leads to permanent enlargement from dilatation of the vessels and hyperplasia of the gland-tissue. Excessive use of the voice, blowing of wind-instruments, carrying heavy loads, frequent ascending of steep hills, frequent sexual excitement, menstruation,

pregnancy, infective diseases, heart-disease, etc. may all act in this direction. A striking instance is the chronic enlargement of the gland from persistent congestion in the peculiar vaso-motor disorder known as Graves' or Basedow's disease (**exophthalmic goitre**); a disease characterised by increased rapidity of the heart's action, increased pulsation in the arteries of the neck and head, and protrusion of the eyeballs from the orbits. If a goitrous tumour can be thus produced it is natural to regard it as due to the increased blood-supply of the organ, which leads to increased nutrition and therefore hypertrophy of the gland-tissue. Such goitres are always found to be highly vascular.

But hyperaemia alone is not enough to account for all goitres, and it fails entirely to explain the fact that goitre prevails much more in some regions than in others. In certain regions indeed a large proportion of the inhabitants are goitrous. Moreover it is observed that families hitherto free from goitre acquire the disease when they move into regions where it is common, and that goitrous patients lose the disease when they are removed to regions where it is unknown. These facts require us to assume that the conditions which favour goitre are to some extent local. This view is corroborated by the fact that even in regions where goitre is endemic there are occasionally regular epidemics of the disease, in which *e.g.* the inmates of garrisons or of institutions simultaneously suffer from rapidly growing thyroid tumours.

This endemic and epidemic mode of occurrence has been accounted for in the most various ways: the air, the soil, the water, the social conditions, all have at one time or another been accused. None of these theories however have met with general acceptance The most probable explanation seems to be that the local exciting cause of goitre is of a miasmatic nature, independent of the altitude and of the temperature of the region, but developing only over certain kinds of rock or soil. BIRCHER, one of the latest writers on the subject, concludes from his minute researches on the distribution of goitre in Switzerland, where the disease is in many parts endemic, that it occurs only on marine deposits of palaeozoic, triassic, or tertiary age; while eruptive volcanic rocks, the older crystalline formations, jurassic and calcareous deposits, and fresh-water deposits generally, are exempt.

The exact nature of the miasma, and its mode of entrance into the body, are as yet unknown. KLEBS and BIRCHER suspect the existence of some specific micro-organism, though they have not succeeded in obtaining any experimental basis for the supposition. It will very probably be found that the exciting agent enters the body in drinking-water. We are also unaware of the manner in which the exciting agent works, but it is not unlikely that it sets up hyperaemic conditions in the thyroid. As infants are sometimes born goitrous, we must assume that it may pass from mother to foetus and influence the latter within the womb. Epidemics of

goitre in goitrous regions indicate that at certain times the conditions favouring infection are exceptionally intense, and cause either an unusual development of the miasma or a temporarily increased predisposition on the part of the persons affected.

In places where goitre is endemic, deaf-mutes, idiots, and so-called cretins are exceptionally numerous. **Cretinism** is a disorder of development essentially affecting the growth of the bones, but accompanied also by morbid changes in the soft parts. These forms of imperfect development have often been correlated with the occurrence of goitre; and it has been suggested that cretinism may be due to the miasma which induces goitre, the latter being as it were a milder form of the same disorder.

BIRCHER formally states his belief that endemic goitre, endemic deaf-mutism, cretinism, and cretinoid idiocy are all due to one and the same miasma. Further research is required before this view can be either accepted or rejected. It has in its favour the fact that cretins and cretinoid idiots are usually also goitrous, and that they are more numerous in regions where goitre is endemic.

HORSLEY (*Brown Lectures, Brit. Med. Journ.* 1, 1885) has shown experimental evidence for the view that cretinism, as also the peculiar cachexia which occasionally follows the extirpation of a goitre (*cachexia strumipriva*), and **myxoedema** are consequences of arrest of the function of the thyroid gland. By removing the gland he succeeded in producing in monkeys a cretinoid state, characterised by hebetude, malnutrition, muscular tremor, puffy oedema, leucocytosis, and the presence of mucin in the blood and connective tissues. Myxoedema in the human subject is a state having the same general characters, and it is associated with wasting of the thyroid gland or its destruction by a new growth.

References :—VIRCHOW, *Gesammelte Abhandl.* 1856 ; ST LAGER, *Étude sur les causes du crétinisme et du goître endémique* Paris 1867 ; LUCKE, *Pitha u. Billroth's Chirurgie* III ; BAILLARGER, *Enquête sur le goître et le crétinisme* Paris 1873 ; DEMME, *loc. cit.* ; FREUND, *Die Bezieh. d. Schilddrüse zu d. weibl. Geschlechtsorganen* In. Diss. Strasburg 1882 ; KLEBS, *Stud. üb. d. Verbreitung d. Kropfes in Oesterreich* Prague 1878 ; ROLL, *Spec. Path. und Therap. d. Hausthiere* 1876 ; HIRSCH, *Handb. d. histor. geograph. Path.* II 1883, trans. by CREIGHTON (New Syd. Soc.) II London 1885 (with ample references to the literature of the subject) ; BIRCHER, *Der endemische Kropf* Basle 1883 ; KRATTER, *Der alpine Cretinismus* Graz 1884 ; HILTON FAGGE, *Prin. and pract. of med.* I London 1886.

On the *cachexia strumipriva*, surgical and experimental, see KOCHER, *Arch. f. klin. Chir.* XXIX 1883 ; REVERDIN and SCHIFF, *Rev. méd. de la Suisse romande* 1883-84 ; WAGNER *Wiener med. Blätter* 1884 ; SANQUIRICO and CANALIS, *Arch. p. l. sci. med.* VIII 1884 ; BRUNS, *Sammlung klin. Vorträge* 244 ; JULLIARD, *Revue de chirurgie* 1883 ; BAUMGARTNER, *Arch. f. klin. Chir.* XXXI 1884 ; GRUNDLER, *Zur Cachexia strumipriva* Tubingen 1884 ; ZESAS, *Deut. Medicinalzeitung* 1885 ; ALBERTONI and TIZZONI, *Cent. f. med. Wiss.* 24, 1885 ; FUHR, *Arch. f. exp. Path.* XXI 1886 (with a discussion of the literature).

For cases of myxoedema see GULL, *Trans. Clin. Soc.* VII 1879 ; ORD, *Med. chir. Trans.* XLIII 1878, *Trans. Clin. Soc.* VIII 1880 ; DYCE DUCKWORTH, *ibid.* ; CAVAFY, *ibid.* XV 1882 ; HARLEY, *Med. chir. Trans.* LXVII 1884 ; Discussion, *Brit. Med. Journ.* 2, 1883 ; WHITE, *Lancet* 1, 1885.

CHAPTER XC.

THE THYMUS GLAND.

623 *b* The **thymus** is a gland-like body, which grows to a considerable size in the foetus and during the first two years of infancy: after that however it ceases to grow, and about the tenth year undergoes retrograde change into fibrous and adipose tissue.

It lies in the superior mediastinum behind the first piece of the sternum, extends upwards nearly to the thyroid, and is made up chiefly of two flat elongated lobes which are in contact or coherent along their medial borders and are enclosed in a thin connective tissue. The lobes are subdivided into lobules by fibrous septa. The structural units or acini closely resemble lymphatic glands, and are composed of a loose reticular or adenoid stroma, filled with indifferent or lymphoid elements and larger multinuclear cells In the peripheral parts of the acinus the stroma is somewhat closer and more densely filled with cells than in the centre, and thus a cortical and a medullary layer are distinguished. The thymus possesses no duct, but it has numerous lymphatics whose exact course is however only imperfectly understood

Small **accessory glands** are not uncommon; they usually lie above the gland and near the thyroid. Congenital absence of the gland occurs only in highly malformed foetuses.

The weight of the thymus in a new-born infant is about 14 grammes, in a child of two it is about 26 grammes. this is subject however to considerable variation.

According to STIEDA, KOLLIKER, HIS, and WATNEY, the thymus developes from the epithelium of a branchial cleft, and is thus originally an epiblastic or epithelial structure The epithelial cells however disappear after a time, and the development of the characteristic lymphadenoid tissue starts from mesoblastic (connective-tissue) elements.

The **function** and exact significance of the thymus is not certainly known. WATNEY, who has made it the subject of extensive investigation, thinks that it takes part in the formation of red and white blood-cells. The former are supposed to be developed in certain nucleated cells containing haemoglobin.

Before birth, and in larger numbers during infancy, the thymus contains homogeneous or indistinctly-laminated partially-calcified bodies known as Hassall's concentric corpuscles. They lie chiefly in the centre of the acini, and are composed of cells closely applied to each other like the coats of an onion. STIEDA regards these as the remains of the rudimental epithelial structures; AMMANN thinks they develope from the stroma-cells or the perithelium of the blood-vessels, or from lymphoid elements whose nucleus and protoplasm have undergone colloid degeneration. The laminated bodies, calcified and uncalcified, break down and disappear during the retrogression of the gland, which is manifested chiefly by the dwindling and disappearance of its cells.

Of **morbid changes** in the thymus the commonest is imperfect retrogression, by which it sometimes persists till the thirtieth or fortieth year.

Haemorrhage into the gland is met with chiefly in asphyxia, or in connexion with the haemorrhagic diathesis (BOUCHER, *Bull. de la soc. anat.* II 1857; ACLAND, *Lancet* 2, 1884 and *Trans. Path. Soc.* XXXVI 1885).

Haematogenous purulent inflammation is usually due to pyaemia and may lead to multiple abscesses or to general suppuration. Suppuration affecting the structures of the neck is apt to extend to the thymus. Nothing is known of chronic indurative change in the gland.

Tuberculosis appears in the form of disseminated nodules, and of large caseous foci.

Gummatous inflammatory change due to syphilis has been several times described.

Primary tumours having the structure of soft or hard lymphosarcoma or of simple sarcoma occur in connexion with general leukaemia and also independently. They appear as soft and marrowy or sometimes moderately firm growths, and at times reach a considerable size. They may compress the air-passages or blood-vessels, or displace the heart or lungs.

References :—KÖLLIKER, *Gewebelehre* Leipzig 1867, and *Entwickelungsgeschichte* Leipzig 1879; AFFANASIEW, *Arch. f. mikrosk. Anat.* XIV (1877); FRIEDLEBEN, *Die Physiol. d. Thymusdrüse* Frankfort 1858; HIS, *Zeitschr. f. wiss. Zoologie* X, XI, and *Menschliche Embryonen* I Leipzig 1880; STIEDA, *Unters. üb. d. gland. thymus gland. thyr. und gland. carotica* Leipzig 1881; VIRCHOW, *Virch. Arch.* vol. 3; GEGENBAUR, *Anatomie* Leipzig 1883; WATNEY, *Phil. Trans.* III 1882; AMMANN, *Beitr. z. Anat. d. Thymus* In. Diss. Basle 1882; DUBOIS, *Gaz. méd. de Paris* 1850 (inflammations); DERAUL, *Mém. de l'acad. de méd.* XVII (inflammations); EBERTH, *Virch. Arch.* vol. 40 (gumma); LANCEREAUX, *Traité d'anat. path.* II Paris 1881; VIRCHOW, *Krankhafte Geschwülste* II; WITTICH, *Virch. Arch.* vol. 8 (lymphoma); STEUDENER, *ibid.* vol. 59 (sarcoma); HAHN and THOMAS, *Arch. générales* 1879; HEDENIUS, *Nord. med. Arkiv* 24, 1878.

SECTION XI.

THE CENTRAL NERVOUS SYSTEM.

CHAPTER XCI.

STRUCTURE AND FUNCTIONS.

624. The **central nervous system** consists of the spinal cord, the cerebral axis, and the cerebrum. These parts are made up of nerve-cells and nerve-fibres, together with a framework of connective tissue which carries the nutrient vessels. The nerve-cells or ganglion-cells are for the most part aggregated in masses which are known as nerve-centres or grey nuclei. The nerve-fibres form either plexuses or tracts, and serve to connect the ganglion-cells of one group with those of another or with the peripheral terminations (end-organs) of certain nerves.

The cord and the cerebral axis contain centres of subordinate importance, forming as it were intermediate stations between the central and peripheral extremities of the nerve-tracts. The cerebrum is the central terminus with which the peripheral sensory and motor end-organs are connected either directly or through the intermediate stations.

The **cerebrum** consists of two hemispheres connected by a commissure, the *corpus callosum*. The outer surface of the hemispheres is thrown into a series of complicated convolutions consisting of ridges and furrows (*gyri* and *sulci*), the latter ramifying and intercommunicating in a remarkable way.

Some of the sulci are characteristic of the human brain, and are always present; others vary in different brains, and thus the configuration of the convolutions is by no means absolutely constant. The most important sulci are—the **sylvian** fissure (Fig. 243 *e*), the **central** or rolandian fissure (*a*), the **praecentral** or transverse-frontal furrow (*b*), the **intraparietal** furrow (*d*), the **first-temporal** or parallel furrow (*f*), the **parieto-occipital** furrow (*c*), the **anterior-occipital** furrow (*i*), and the **inferior-occipital** furrow (*h*).

The central fissure divides the cerebral hemisphere into an anterior and a posterior portion; the (central) convolutions which form its anterior and posterior borders are known as the anterior-central or **ascending-frontal** (*A*), and the posterior-central or **ascending-parietal** (*B*). The portion of the hemisphere in front of the central

fissure is the **frontal lobe**, and includes the ascending-frontal (A), the superior-frontal (C_1), middle-frontal (C_2), and inferior-frontal (C_3) convolutions. The last three convolutions all pass round to the orbital surface of the hemisphere.

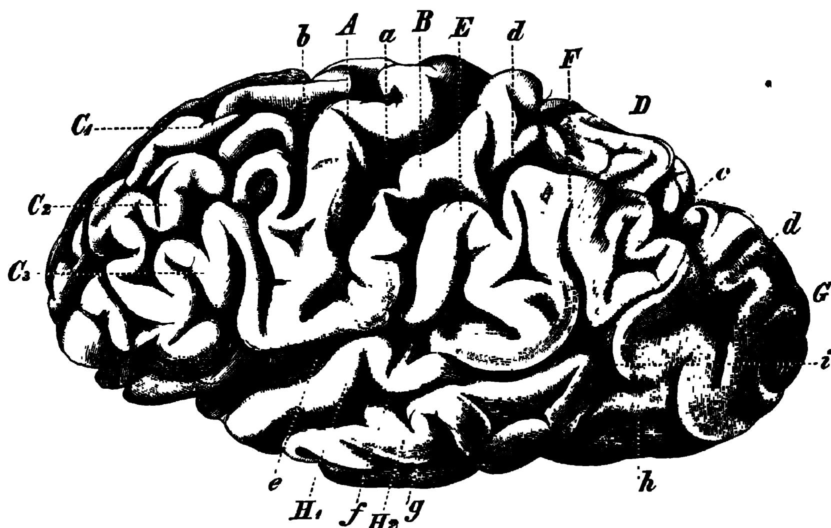


FIG. 243. OUTER SURFACE OF THE LEFT CEREBRAL HEMISPHERE.
(*From a brain hardened in nitric acid and dried*)

central or rolandian fissure	A ascending-frontal convolution
praecentral furrow	B ascending-parietal convolution
parieto-occipital furrow	C_1 superior-, C_2 middle-, C_3 inferior-frontal convolution
intraparietal furrow	D superior-parietal lobule
sylvian fissure	E marginal convolution } inferior-parietal lobule
first-temporal or parallel furrow	F angular convolution } inferior-parietal lobule
second-temporal furrow	G occipital lobe
inferior-occipital furrow	H_1 first-temporal, H_2 second-temporal, convolution
anterior-occipital furrow	

Immediately behind the ascending-parietal convolution (B), and divided from it by the intraparietal furrow (d), lies the superior-parietal lobule (D); the inferior-parietal lobule being made up of the marginal (or supramarginal) convolution (E) and the angular convolution (F). These ($BDEF$) constitute the **parietal lobe.**

The parieto-occipital furrow (c) and the anterior-occipital furrow (i) separate the parietal from the **occipital lobe** (G), and in the space between the two furrows the so-called annectant (or connecting) convolutions pass over from the parietal lobe to the occipital lobe.

The sylvian fissure (e) forms the boundary between the outer and lower portions of the frontal and parietal regions and the **temporal lobe.** The convolution bordering the lower side of the fissure is the first-temporal or superior temporo-sphenoidal (H_1).

The convolution which curves round the upper end of the sylvian fissure is assigned to the parietal lobe and is called the marginal convolution (E). Beneath the first-temporal convolution lies the first-temporal or parallel furrow (f), and beneath that the second-temporal convolution (H_2). Springing from the upper part of the latter convolution the angular gyrus or convolution (F) curves round the end of the first-temporal furrow (f): it also is assigned to the parietal lobe. Beneath the second-temporal furrow (g) lies the third-temporal convolution (Fig. 244 t^3).

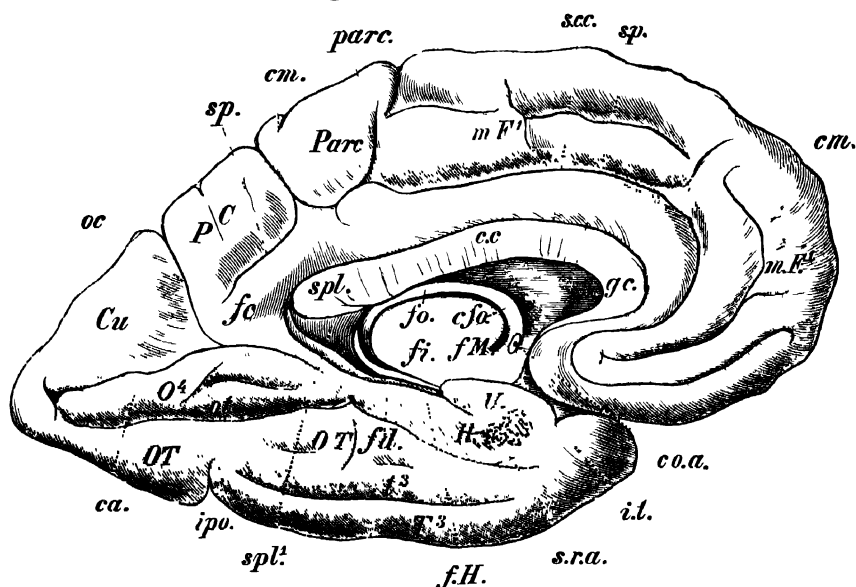


FIG. 244. MEDIAN SURFACE OF THE LEFT CEREBRAL HEMISPHERE (*after SCHWALBE*)

cm	calloso marginal fissure	*coa*	corpus albicans
scc	sulcus of the corpus callosum	*mF*[1]	superior-frontal convolution
oc	parieto occipital furrow	*H*	hippocampal gyrus
sp	subparietal furrow	*Parc*	paracentral lobule
s.p	septum lucidum	*PC*	quadrate lobule (praecuneus)
ca	calcarine fissure	*Cu*	cuneus
ipo	*incisura praeoccipitalis*	*O*[4]	uncinate gyrus (lingualis)
ot	occipito-temporal (or collateral) furrow	*OT*	occipito-temporal convolution
t[3]	third-temporal furrow	*T*[3]	third temporal convolution
fH	hippocampal (or dentate) fissure	*U*	uncus of uncinate gyrus
it	*incisura temporalis*	*fd*	fascia dentata
cc	corpus callosum	*fi*	fimbria
gc	genu	*fM*	foramen of Monro
spl	splenium	*sra*	substantia reticularis alba
fo	fornix	*fc*	gyrus fornicatus or convolution of the corpus callosum
cfo	anterior pillar (columna) of the fornix		

If next the lips of the sylvian fissure be separated the **central lobe** or island of Reil becomes visible

The **median surface** of the superior-frontal convolution (mF^1)

has no special name: the median surface of the ascending (frontal and parietal) convolutions that border the central fissure is called the paracentral lobule (*Parc*). Both are bounded inferiorly by the calloso-marginal fissure (*cm*), which anteriorly separates the superior-frontal convolution from the convolution of the corpus callosum (*gyrus fornicatus* or *cinguli fc*), and posteriorly separates the paracentral lobule from the quadrate lobule (or *praecuneus PC*), the median portion of the superior-parietal lobule. The median portion of the occipital lobe is called the *cuneus* or cuneate lobule (*Cu*), and is parted from the quadrate lobule by the parieto-occipital furrow (*oc*).

The calcarine fissure (*ca*) separates the cuneus from the uncinate gyrus (*gyrus lingualis* O^4); the latter passes forward and becomes the hippocampal gyrus (*H*).

Beneath the uncinate gyrus lies the occipito-temporal or collateral furrow (*ot*), and beneath this the occipito-temporal convolution (*gyrus fusiformis OT*).

625. The mass of the cerebrum consists of cortical or grey matter (Fig. 245 *co*) and medullary or white matter. The former is of a soft-grey tint and forms the surface layer of all the convolutions; it also occurs at the base of the brain in the masses known respectively as the claustrum (*cl*), the nucleus amygdalae (*na*), the caudate nucleus (*nc*), and the outer portion of the lenticular nucleus. These latter are all connected anteriorly with one another and with the cortical grey matter (anterior perforated space). Posteriorly they are separated by intervening portions of white matter.

The grey masses known as the optic thalamus or simply thalamus (*th*), the subthalamic body or nucleus of Luys (*cs*), and the inner two-thirds of the lenticular nucleus (*nl*) do not strictly lie within the cerebral hemispheres but belong to the cerebral axis.

The cortical **grey matter** consists of a delicate fibrous meshwork (neuroglia) which in the dead brain is finely granular, enclosing a number of multipolar ganglion-cells, and nerve-fibres of various thickness arranged in plexuses and tracts.

The medullary or **white matter** is composed chiefly of medullated nerve-fibres devoid of primitive sheaths, all of them originating in the grey substance.

The fibres starting from the cortex form bundles which pass into the white *centrum ovale* of the hemisphere. Those from the central region form the *corona radiata*, and for the most part pass down to the base of the brain; the others connect the various convolutions with one another and are spoken of as associating or interconnecting fibres.

Some of these bundles or tracts have received special names: adjacent convolutions are connected by the *fibrae propriae* (GRATIOLET); the orbital convolutions of the frontal lobe are connected with the anterior parts of the temporal lobe by the fibres of the uncinate fasciculus, which passes across the bottom of the sylvian

fissure; the corpus callosum connects corresponding cortical regions in the two hemispheres; the anterior (or white) commissure connects the two olfactory lobes and the two temporal lobes;

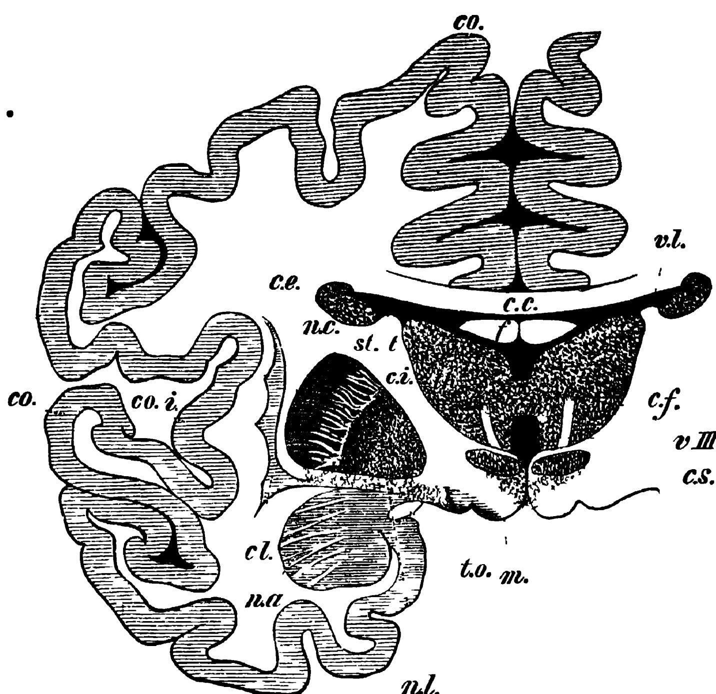


FIG. 245. DIAGRAMMATIC TRANSVERSE VERTICAL SECTION OF THE CEREBRUM (*after* SCHWALBE).

co	cortex	*ci*	internal capsule
coi	island of Reil	*ce*	external capsule
cl	claustrum	*stt*	stria terminalis (taenia semicircularis)
na	nucleus amygdalae	*cf*	anterior pillar of the fornix
nc	caudate nucleus	*f*	fornix
th	optic thalamus	*cc*	corpus callosum
cm	middle commissure	*v III*	third ventricle
cs	subthalamic body	*vl*	lateral ventricle
m	substantia nigra	*to*	optic tract
nl	lenticular nucleus		

the arcuate fasciculus consists of fibres passing over the corpus callosum from the frontal lobe to the occipital lobe; and so on.

The **cortex** is the terminal station for all nerves. Every part of the sensorial surface of the body and the whole muscular system are connected by nerve-tracts (the 'projective system') with the cortex. By means of these tracts impressions corresponding to every sensory stimulus and to every muscular movement are conveyed to the cortex; and these impressions probably leave traces or 'memories' in the ultimate structure of the grey matter

(MEYNERT). These traces or memories form the physical substratum of our psychical existence, of our consciousness. The traces are not diffused indiscriminately over the surface of the brain, but tend to become associated with certain parts; and thus the various sensory surfaces and the various groups of muscles come into definite relation with certain definite regions of the cortex. These **cortical centres** or areas are however not sharply circumscribed, but encroach upon one another at many points.

The researches of BOUILLAUD, BROCA, MEYNERT, KUSSMAUL, HUGHLINGS-JACKSON, HITZIG, FRITSCH, FLECHSIG, WERNICKE, MUNK, FERRIER, CHARCOT, HUGUENIN, PITRES, LÉPINE, MARCACCI, BÄUMLER, EXNER, TRIPIER, PETRINA, KAHLER, PICK, and others have determined the position of these areas or centres for various functions and movements, and this not only in man but in a number of other animals. Thus it is almost certain that the centre for the co-ordination of the movements of speech is placed chiefly in the inferior-frontal convolution on the left side, and the centre for auditory perception in the first-temporal convolution. Destruction of the former centre involves the loss of power to perform the movements necessary for articulate speech (aphemia or motor aphasia); and on destruction of the latter centre the patient is unable to understand spoken words (word-deafness or sensory aphasia). The centre for visual perception appears to lie chiefly in the angular gyrus and occipital lobe. The motor and sensory centres for the limbs lie in the central convolutions (ascending-frontal and ascending-parietal), the paracentral lobule, and the parts adjoining.

FLECHSIG divides the surface of the brain into three great regions having distinct functions—they are the frontal zone, the parietal zone, and the temporo-occipital zone. The parietal zone contains the starting-points of the direct motor tracts and the terminal-points of most of the sensory tracts: it may therefore be described as the sensory-motor zone. The frontal and temporo-occipital zones have no direct relations to the motor tracts, but are connected with the optic thalamus, the pons, and the cerebellum. Both zones are, he considers, in close relation with the psychical processes, and the parts of them bordering on the parietal zone have an important connexion with the function of speech.

The following are a few of the more important works bearing on the anatomy of the brain:—MEYNERT, *Vierteljahrsschrift für Psychiatrie* I (1867), *Anatomie d. Hirnrinde etc.* Erlangen 1865, *Wiener med. Jahrb.* 1866, *Arch. f. Psych.* VII (1877), *Das Gehirn d. Säugethiere* in *Stricker's Gewebelehre* 1870 (trans. as *Manual of Histology* II London 1872), *Psychiatry* (trans. by SACHS) London 1885; ECKER, *Die Hirnwindungen d. Menschen* Brunswick 1883 (first edition trans. by GALTON, London 1873); BISCHOFF, *Die Grosshirnwindungen d. Menschen* Munich 1868; HUGUENIN, *Allg. Pathol. d. Nervensystems* I Zürich 1873; HENLE, *Nervenlehre* Brunswick 1879; SCHWALBE, *Lehrb. d. Neurologie* Erlangen 1881 (with very full references); PANSCH, *Arch. f. Anthrop.* III; FLECHSIG, *Die Leitungsbahnen im Gehirn u. Rückenmark d. Menschen* Leipzig 1876, *Plan d. menschlichen Gehirnes* Leipzig 1883; WERNICKE, *Arch. f. Psych.*

VI (1876), *Lehrbuch d. Gehirnkrankh.* I 1881; VON MICHALKOVICZ, *Entwickelungsgeschichte d. Gehirnes* Leipzig 1877; GUDDEN, *Arch. f. Psych.* II, *Corresp. f. Schweizer Aerzte* 1872, *Grafe's Arch. f. Ophthalm.* XX; FOREL, *Arch. f. Psych.* VII; GIACOMINI, *Arch. ital. de biol.* I (1882), *Guido allo studio delle circonvoluzione cerebrali dell' uomo* Turin 1878; MARCACCI, *Arch. ital. de biol.* I; GOLGI, *ibid.* III, IV; DALTON, *Brain* III (1881), *Topograph. anat. of the brain* Philadelphia 1885; *Quain's Elements of anatomy* II London 1882; ROSS, *Diseases of the nervous system* London 1883; AEBY, *Schema d. Faserverlaufes v. menschl. Gehirn* Berne 1884; EDINGER, *Bau d. nerv. Centralorgane* Leipzig 1885; HILL, *Plan of the central nervous system* Cambridge 1885.

On the functions of the brain:—BOUILLAUD, *Traité clinique de l'encéphalite* Paris 1825; FLOURENS, *Arch. générales de méd.* II (1823), *Recherches expér. sur le système nerveux* Paris 1824 and 1842; FRITSCH and HITZIG, *Reichert's Arch.* 1870; HITZIG, *Unters. üb. das Gehirn* Berlin 1874; VEYSSIÈRE, *L'hémianesthésie de cause cérébrale* Paris 1874; CARVILLE and DURET, *Arch. de physiol.* II (1875); NOTHNAGEL, *Virch. Arch.* vols. 57, 58, 60, 62; SCHIFF, *Lezione sopra il syst. nerv. encephal.* Florence 1874, *Arch. f. exper. Pathol.* III (1875); FERRIER, *West Riding Asylum Reports* 1873, *Phil. Trans.* CLXV (1875), *Functions of the brain* London 1886; GOLTZ, *Pfluger's Arch.* vols. 13, 14 and 20, *Trans. internat. med. congress* I London 1881, *Ueber die Verrichtungen d. Grosshirnes* Bonn 1881; BURDON-SANDERSON, *Proc. Roy. Soc* XXII (1875); HERMANN, *Pfluger's Arch.* vol. 10; MUNK, *Ueber d. Functionen d. Grosshirnrinde* Berlin 1881, *Sitzungsber. d. Berlin. Acad.* XXXVI (1882); VETTER, *D. Arch. f. klin. Med.* XV, XXII, XXXI; MEYNERT, *Wiener Sitzungsber.* 1869, *Arch. f. Psych.* II (1870), *Mechanik d. Gehirnbaues* Vienna 1874; LÉPINE, *Localisat. dans les malad. cérébrales* Paris 1875; HUGHLINGS-JACKSON, *Researches on the nervous system* London 1875, *Croonian lectures* on *The evolution and dissolution of the nervous system* London 1884; CHARCOT and PITRES, *Revue mens. de méd.* 1877-79, *Revue de méd.* 5, 1883; NOTHNAGEL, *Topische Diagnostik d. Gehirnkrankh.* Berlin 1879; KAHLER and PICK, *Prager Vierteljahrs.* 141, *Prager Zeitschrift f. Heilk.* I; FURSTNER, *Arch. f. Psych.* VIII; PITRES, *Rech. sur les lésions du centre ovale des hémisphères cérébr.* Paris 1878; BROCA, *Bull. de la soc. anatom.* 1861 and 1863, *Revue d'anthropologie* V (1876); KUSSMAUL, *Die Storungen d. Sprache* Leipzig 1877; BERGER, *Arch. d. Heilk.* 1878; OBERSTEINER, *Wien. med. Jahrb.* 1878; WERNICKE, *Der aphasische Symptomencomplex* Breslau 1874; BASTIAN, *Brain as an organ of mind* (Int. scientific series) London 1885; MARCACCI, *Arch. ital. de biol.* I, II; GOLGI, *ibid.* II; CHARCOT, *Leçons sur les localisations dans les maladies du cerveau* Paris 1878, trans. by HADDEN (New. Syd. Soc) London 1883; EXNER, *Unters. ub. die Function d. Grosshirnrinde* Vienna 1880; SKWORTZOFF, *De la cécité et de la surdité des mots dans l'aphasie* Paris 1881; TRIPIER, *Revue mens.* 1880; PETRINA, *Zeitschr. f. Heilk.* II; ROSS, *op. cit.*; GOWERS, *Diseases of the brain* London 1885; LANDOIS and STIRLING, *Human Physiology* II London 1886.

On loss of vision (hemianopsia) after lesion of the occipital lobe:—FÖRSTER, *Gräfe-Saemisch's Handbuch* VII; HITZIG, *Corresp. f. Schweizer Aerzte* 1877; MUNK, *Berl. klin. Woch.* 1877, *Du Bois-Reymond's Arch.* 1878; JASTROWITZ, *Centralb. f. Augenheilk.* 1877; BAUMGARTEN, *Cent. f. med. Wiss.* 1878; HOSCH, *Klin. Monatsbl. f. Augenheilk.* XVI; NOTHNAGEL, *loc. cit.*; CURSCHMANN, *Centralb. f. Augenheilk.* 1879; WESTPHAL, *Berl. klin. Wochenschr.* 1880; WERNICKE and HAHN, *Virch. Arch.* vol. 87; MARCHAND, *Grafe's Arch.* XXVIII; RICHET, *Structure des circonvolutions* Paris 1878; FURSTNER, *Arch. f. Psych.* VIII; HAAB, *Klin. Monatsbl. f. Augenheilk.* 1882; FERRIER and YEO, *Brit. Med. Journ.* 2, 1880; FERRIER, *Brain* III (1880), VII (1884), and *op. cit.*; PIERSON, *Cent. f. Nervenheilk.* 1880; MAUTHNER, *Gehirn und Auge* Wiesbaden 1881; WILBRAND, *Ueber Hemianopsie* Berlin 1881, *Ophthalm. Beiträge z. Diagnostik d. Gehirnkrankh.* Wiesbaden 1884; STARR, *Amer. Journ. med. sci.* 1884; FÉRÉ, *Arch. de neurologie* IX (1883); HAMILTON, *Brain* VII (1884). A summary of cases is given by ROSS, *op. cit.* II, DODDS, *Brain* VIII (1885), and SEGUIN, *Journ. of nerv. and ment. disease* 1886.

626. The **spinal cord** is an elongated cylindrical body, somewhat flattened antero-posteriorly, and composed of grey matter and white matter The **grey matter** is in the interior, extending throughout the length of the cord, the cross-section being roughly H-shaped (Fig 246) and forming two **anterior horns** (or *cornua, ca*) and two **posterior horns** (*cp*), united by a grey commissure. The commissure contains the **central canal** (*cc*), a slender tube lined with epithelium The anterior horns are of larger sectional area than the posterior, but their size and configuration vary remarkably in different parts of the cord: they are smallest in the dorsal region.

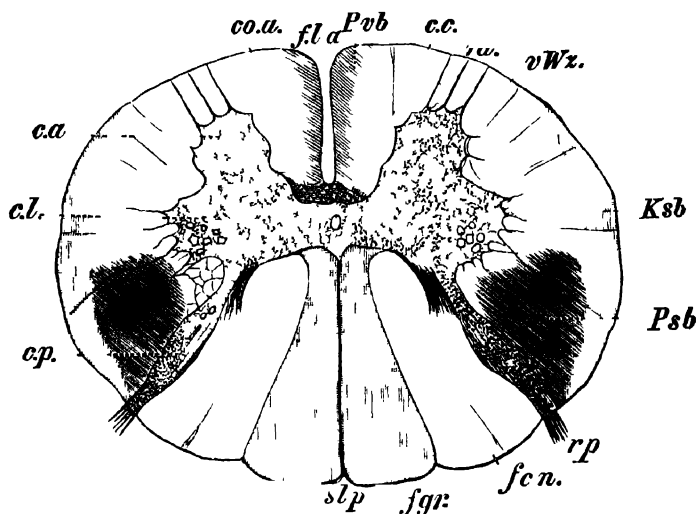


FIG. 246. DIAGRAMMATIC SECTION OF THE SPINAL CORD (× 6).

ca	anterior horn	*fla*	anterior longitudinal fissure
cl	lateral horn (so-called)	*slp*	posterior longitudinal fissure
cp	posterior horn	*fgr*	funiculus gracilis (column of Goll)
cc	central canal	*Psb*	lateral (or crossed) pyramidal tract
coa	anterior or white commissure	*Pvb*	anterior (or direct) pyramidal tract (column of Turck)
fcn	funiculus cuneatus (posterior root-zone or column of Burdach)	*vWz*	anterior root zone
Ksb	direct cerebellar tract		
ra	anterior root		
rp	posterior root		

In numerous places, especially about the region midway between the anterior and posterior horns, radiating processes of grey matter pass into the white (near *c l*), and are known as *processus reticulares.* They interlace and form a network enclosing portions of white substance in its meshes In the cervical and upper dorsal regions a lateral projection of the anterior horn appears, and is called the **intermedio-lateral tract** or lateral horn (*c l*)

The grey substance contains a multitude of ganglion-cells and nerve-fibres of various thicknesses, enclosed in a delicate neuroglia. Round the central canal and at the extremity of the posterior

horn the neuroglia is rich in cells, and ganglion-cells are absent: these parts are spoken of as the *substantia gelatinosa,* the parts containing ganglion-cells as the *substantia spongiosa.*

In the anterior horn the ganglion-cells (motor cells) are large and multipolar; they possess numerous processes, one long and unbranched is the axis-cylinder process, the others subdividing and interlacing into a delicate network of fibrils. The anterior ganglion-cells are gathered into clusters, corresponding apparently to the territories of the blood-vessels. In the posterior horns they are much smaller and more uniformly distributed. Two longitudinal columns of bipolar ganglion-cells exist in the dorsal region of the cord, lying to the median side of the inner portion of the posterior horns and known as Clarke's vesicular columns; these contain ganglion-cells intermediate in size between those of the anterior and those of the posterior horns.

The **white matter** of the cord forms a sheath surrounding the grey columns and filling up their irregularities. It is cleft behind by the slender posterior sulcus or fissure (*slp*) which extends to the grey matter, and anteriorly by the wider anterior fissure (*fla*) which does not quite reach the grey matter but leaves a narrow white or anterior commissure (*coa*) to unite the lateral halves of the cord. The white matter consists of large and small medullated nerve-fibres (without the primitive sheath of Schwann) running for the most part longitudinally; only a few run horizontally or obliquely. These fibres are divided into bundles by fibrous and neurogliar dissepiments extending inwards from the surface. Externally the cord is covered with a thin layer of greyish neuroglia. Very few ganglion-cells are met with in the white matter.

The **roots** of the spinal nerves are bundles of fibres leaving the cord anteriorly and posteriorly in more or less parallel directions. The anterior root (*ra*) contains motor fibres and starts proximately from the anterior horn: the posterior root (*rp*) conveys centripetal or sensory fibres to the posterior horn. A certain number of anterior-root fibres and posterior-root fibres unite into a nerve, and to each pair of nerves corresponds a more numerous aggregation of ganglion-cells; consequently the cord is subdivided into a number of natural segments whose number corresponds to that of the spinal nerves.

The portion of white matter between the anterior fissure and the anterior root is called the **anterior column**; that between the anterior and posterior root on the same side is the **lateral column**; that between the posterior root and the posterior fissure is the **posterior column**.

The fibres passing into the roots are connected with the ganglion-cells of the anterior horn by means of the axis-cylinder process, with those of the posterior horn by the network of fibrils; in the latter the ganglion-cell processes and the nerve-fibres inter-

lace. From the grey matter other nerve-fibres pass into the neighbouring white columns, which either serve to connect parts of the grey matter on different levels or pass directly upwards to the base of the brain or the cerebrum.

The longitudinal columns are subdivided into various tracts according to their physiological function. The best-known are the anterior (or direct) and lateral (or crossed) pyramidal tracts (*Pvb*, *Psb*), the lateral or direct cerebellar tract (*Ksb*), the column of Goll or *funiculus gracilis* (*fgr*), and the posterior root-zone or *funiculus cuneatus* (*fcn*).

The **anterior pyramidal tract** (column of Türck) and the **lateral pyramidal tract** contain centrifugal or efferent fibres, and form the direct path of communication between the grey matter of the parietal zone of the cerebral cortex and that of the anterior horns. They traverse the internal capsule (Fig. 245 *ci*) and the peduncular tract, the lateral tract passing to the opposite side at the decussation of the pyramids, and the anterior tract passing directly down on the same side and crossing at some point in the cord by means of the anterior commissure to join the anterior horn of the opposite side.

The anterior tract (*Pvb*) lies medially in the anterior column, the lateral tract (*Psb*) in the posterior part of the lateral column. The cross-section of each diminishes as we pass downwards from the medulla. The relative size of the crossed and uncrossed portions is very variable and in some cases unequal on the two sides, the section of the cord being then unsymmetrical. Usually the anterior tract disappears about the middle of the dorsal region. In some cases however it extends down to the lumbar region, and in others is entirely absent, that is to say the decussation at the pyramids is complete.

The **direct cerebellar tract** (*Ksb*) connects the grey matter of Clarke's column with the cerebellum. It runs along the outer margin of the posterior portion of the lateral column, and extends as far as the end of the dorsal region.

The remaining region of the anterior column is termed by FLECHSIG the **principal tract** of the anterior column, and that of the lateral column the **mixed lateral tract**. The fibres in these regions serve apparently to connect different portions of the grey matter of the cord with one another and with the brain, and include root-fibres which course longitudinally for a short distance along the cord before entering the grey horns.

The median portion of each **posterior column** is called the **column of Goll** or *funiculus gracilis* (*fgr*); the lateral portion (*fcn*) is the **column of Burdach** or cuneate funiculus. The column of Goll connects the posterior roots of the cord with the tegmental region of the medulla, *i.e.* with the nucleus of the funiculus gracilis (Fig. 249 *ng*), probably also with the internal accessory olivary nucleus (*oam*), and thence by way of the internal capsule and the corona radiata with the parietal zone of the

cortex and the lenticular nucleus. The column of Burdach (Fig. 243 *fcn*) contains fibres which enter with the posterior roots and then pass upwards for a certain distance, ultimately entering the posterior horn. It also contains fibres interconnecting various portions of grey matter in the cord, and connecting these with the nucleus of the funiculus cuneatus and olivary body in the medulla, with the dentate nucleus in the cerebellum, and thence with the parietal zone of the cortex and the corpus striatum (FLECHSIG). According to KAHLER the ascending nerve-fibres

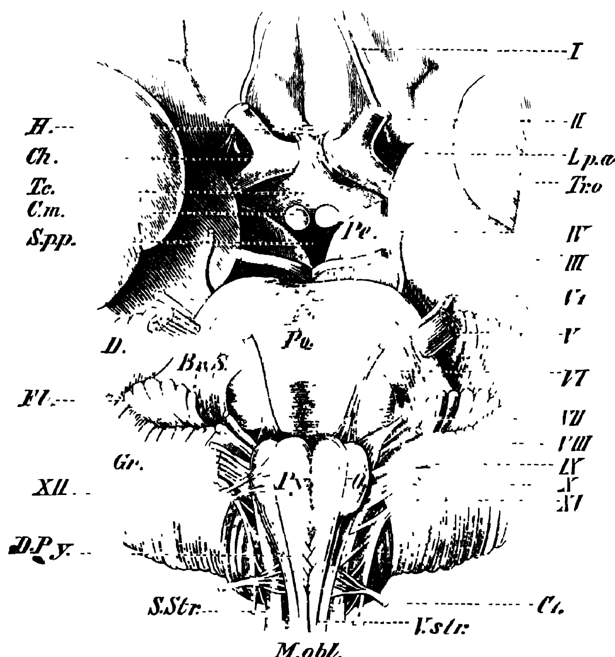


FIG. 247. BASAL ASPECT OF THE CEREBRAL AXIS.

Mobl medulla oblongata
Sstr lateral column
Vstr anterior column
Py pyramid
DPy decussation of the pyramids
O olivary body
Po pons
D anterior lobe of the cerebellum
Gr digastric lobe of the cerebellum
Fl flocculus of the cerebellum
BrS middle peduncle of the cerebellum
Pe crus cerebri (cerebral peduncle)
Spp posterior perforated space
Lpa anterior perforated space
Cm corpora albicantia (mammillaria)
Tc tuber cinereum with infundibulum

H stem of the hypophysis or pituitary body
TrO optic tract
Ch optic chiasma
I olfactory nerve
II optic nerve
III oculomotor nerve
IV trochlear nerve
VV_1 trigeminus nerve
VI abducens nerve
VII facial nerve
VIII auditory nerve
IX glossopharyngeal nerve
X vagus nerve
XI spinal accessory nerve
XII hypoglossal nerve
C_1 anterior root of first cervical nerve

from the posterior roots are so arranged that in any given section of the cord those fibres which entered lowest lie nearest the posterior end of the median fissure.

The grey matter of the cord contains the several nerve-centres subordinate to those in the medulla; these centres subserve simple or partial and diffuse or co-ordinated reflexes, and on stimulation of the sensory or afferent fibres may give rise to motor impulses which act on associated or distinct groups of muscles and result in motions of a complicated kind. Such are the centres for defaecation, for micturition, for erection and ejaculation, and for various vaso-motor actions.

The fibres connecting the cord with the brain subserve the perception of sensations, and the transmission of impulses inhibiting reflex actions and calling forth voluntary movements.

On the structure and functions of the cord:—TÜRCK, *Wiener Sitzungsberichte* 1851, 1853, 1855; VAN DER KOLK, *Structure and functions of the spinal cord* (New Syd. Soc.) London 1859; GOLL, *Denkschr. d. med. chir. Gesellsch. d. Cant. Zürich* 1860; DEITERS, *Untersuch. üb. Gehirn u. Rückenmark* 1865; BOUCHARD, *Archives gén.* 1866; M. SCHULTZE, *Stricker's Manual of Histology* (New Syd. Soc.) II London 1872; GERLACH, *ibid.*; LEYDEN, *Klinik d. Rückenmarkskrankh.* Berlin 1874; HUGUENIN, *Allg. Path. d. Krankh. d. Nervensyst.* Zürich 1875; BOLL, *Histol. d. nerv. Centralorg.*, *Arch. f. Psych.* IV; SCHIEFFERDECKER, *Beiträge z. Kenntniss d. Faserverlaufes im Rückenmark*, *Arch. f. mikros. Anat.* X (1874), *Virch. Arch.* vol. 67; EICHHORST, *ibid.* vol. 64; FLECHSIG, *Die Leitungsbahnen im Gehirn u. Rückenmark* Leipzig 1876, *Arch. d. Heilk.* XVIII, XIX, *Ziemssen's Cyclop.* (supp. vol.); ERB, *Ziemssen's Cyclop.* XIII; KLEIN and NOBLE SMITH, *Atlas of Histology* London 1880; CHARCOT, *Diseases of the nervous system* (New Syd. Soc.) London 1876-80, *Localisation of cerebral and spinal diseases* (New Syd. Soc.) London 1883; SINGER, *Wiener Sitzungsberichte* 1881; DEBOVE and GOMBAULT, *Arch. de neurologie* I (1881); SCHWALBE, *Lehrb. d. Neurologie* Erlangen 1881; ROSS, *Diseases of the nervous system* I London 1883; BYROM BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; KAHLER, *Naturforscherversammlung in Eisenach* 1882; LAURA, *Arch. ital. de biol.* I (1882); *Quain's Elements of anatomy* II London 1882; BECHTEREW, *Neurol. Centralb.* 1885; HOMÉN, *Fortschritte d. Med.* III 1885; LANGLEY, *Brain* VIII 1886 (a critical digest of memoirs on the tracts of the cord, with references); FERRIER, *Functions of the brain* London 1886.

627. The **cerebral axis** consists of the medulla oblongata (Fig. 247 *Mobl*), the pons Varolii (*Po*), the crura cerebri (*Pe*), the subthalamic (or interpeduncular) region (Fig. 245 about *cs*) with the tuber cinereum (Fig. 247 *Tc*), corpora albicantia (or mammillaria *Cm*), the cerebellum (*D*, *Gr*, *Fl*), the corpora quadrigemina (Fig. 248 *h*), and the optic thalamus (Fig. 245 *th*).

Genetically all these are but modified parts of the spinal cord (SCHWALBE), and from this region arise those cranial nerves which are homologous with the spinal nerves.

The modifications which the cord undergoes in this region are chiefly these—the central canal becomes more and more posterior and is continued into the cerebral axis as the fourth ventricle, the aqueduct of Sylvius, and the third ventricle. At the same time the grey matter subdivides, and interpenetrating the white

assumes a peculiar reticulated structure (Fig. 249 *Fr*) with numerous detached clusters of ganglion-cells from which the cranial nerves take their origin (Fig. 248).

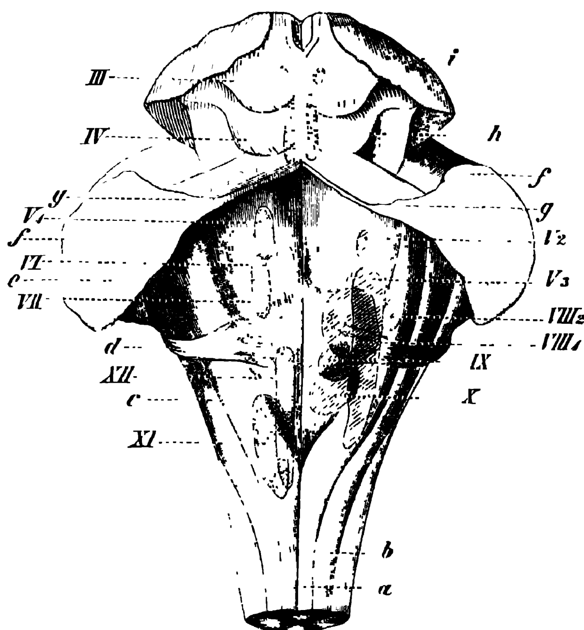


FIG. 248. DIAGRAM OF THE NUCLEI OF THE CRANIAL NERVES.

funiculus gracilis
funiculus cuneatus
restiform body
striae acusticae
posterior peduncle of the cerebellum
middle peduncle of the cerebellum
anterior peduncle of the cerebellum
corpora quadrigemina
crus cerebri

III nucleus of the oculomotor
IV nucleus of the trochlear
V_1 nucleus of the motor, V_2 V_3 nuclei of the sensory, root of the trigeminus
VI nucleus of the abducens
VII nucleus of the facial
$VIII_1$ $VIII_2$ nuclei of the auditory
IX nucleus of the glossopharyngeal
X nucleus of the vagus
XI nucleus of the spinal accessory
XII nucleus of the hypoglossal

This subdivision of the grey matter is accompanied by certain re-arrangements of the nerve-tracts. The pyramidal lateral columns cross each other at the decussation (Fig. 247 *DPy*), and pass to the ventral surface of the medulla (Fig. 249 *p*), while the shorter tracts connecting the several portions of the grey matter become less and less superficial. The column of Goll and the column of Burdach pass up (as the funiculus gracilis (Fig. 248 *a*) and funiculus cuneatus (*b*) respectively) to the lateral margin of the fourth ventricle, and together with lateral cerebellar tract and the arciform fibres of the restiform body (*c*) form the posterior peduncle of the cerebellum (*e*).

At this level fresh nuclei begin to appear, and form the substance of the olivary body (Figs. 247, 249 *o*), and the beginning of the grey matter of the cerebellum, corpora quadrigemina (Fig. 248 *h*), optic thalamus (Fig. 245 *th*), subthalamic body (*cs*), and

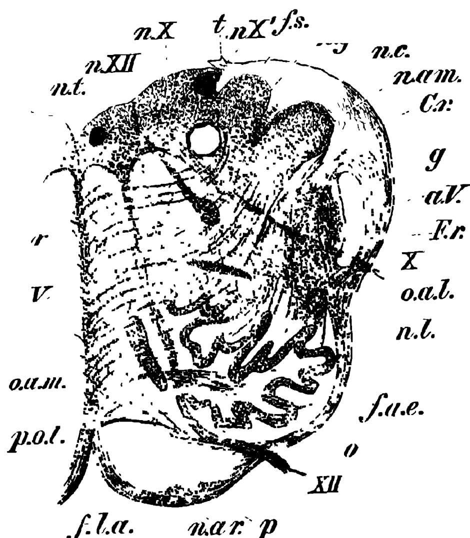


FIG. 249. SECTION OF THE MEDULLA THROUGH THE MIDDLE OF THE OLIVARY BODY. (*After* SCHWALBE: × 4)

nt nucleus of the funiculus teres
nXII nucleus of the hypoglossal nerve
nX nX_1 nucleus of the vagus nerve
XII hypoglossal nerve
X vagus nerve
o olivary nucleus (*corpus dentatum*)
oal exterior accessory olivary nucleus
oam interior accessory olivary nucleus
nam nucleus ambiguus
nl nucleus of lateral column
ng nucleus of funiculus gracilis
nc nucleus of funiculus cuneatus
nar nucleus arciformis
g substantia gelatinosa
aV ascending root of trigeminus
fs funiculus solitarius
t origin of the *ligula* (taenia sinus rhomboidalis)
Cr restiform body
p pyramid
fae external arciform fibres passing in part through the substantia gelatinosa (*g*), in part external to the restiform body (*Cr*)
Fr formatio reticularis, showing internal arciform fibres; the latter partly continuous with the external arciform fibres, partly arising from the various grey nuclei and passing towards the raphe (*r*)
pol olivary arciform fibres (*pedunculus olivae*)
V continuation of anterior column of cord
fla anterior median fissure

numerous small masses (Fig. 249) embedded in the various columns and tracts. All these nuclei give rise in their turn to fresh bundles of fibres, some of which run in distinct tracts while others interlace with their neighbours.

Presently the longitudinal fibres are crossed by numerous arciform fibres (Fig. 249) some external (*fae*), others lying deeper (*Fr, b*) and forming a network (*formatio reticularis*) with the longitudinal fibres.

The cerebral axis may be considered as made up of three regions or strata (SCHWALBE)—the peduncular tract (MEYNERT, SCHWALBE), the tegmental region (FOREL), and the dorsal stratum.

The **peduncular tract** is in the **medulla** represented by the pyramidal columns (Fig. 249 *p*), which are surrounded and in part reinforced by the external arciform fibres (*fae*). The external arciform fibres enclose a nucleus known as the arciform nucleus (*nar*). In the **pons** the peduncular tract lies in the ventral stratum, being crossed and interlaced by the transverse arciform fibres derived from the middle peduncle of the cerebellum (Fig. 247 *BrS*). Some of these fibres are commissural and connect the two halves of the cerebellum; others penetrate the grey masses embedded among the arciform fibres and known as the nuclei of the pons. Certain of the nerve-fibres which start from these nuclei join the bundles of pyramidal fibres and pass with them up to the cerebrum.

The bundles of pyramidal fibres, which in the pons are more or less subdivided and scattered, unite again into compact bundles on the anterior or cerebral side of the pons and, reinforced by the nuclear fibres just referred to, form the pes or crusta of the **crura cerebri** (Fig. 247 *Pe*). The crusta is covered on the upper or dorsal surface by the substantia nigra, a layer of pigmented ganglion-cells, which in their turn give off fibres to join the crustal fibres. These latter then pass (mainly through the internal capsule) up to the cortex. The pyramidal fibres terminate in the ascending frontal and parietal convolutions and the parts adjoining, the other fibres pass to the frontal, temporal, and occipital lobes. A few enter the lenticular and caudate nuclei.

The **tegmental region** lies to the dorsal surface of the peduncular tract, and consists chiefly of the formatio reticularis (Fig. 249 *Fr*). The reticular structure is due to the subdivision into fibres of part of the grey matter of the anterior horn, with which are interlaced numerous arciform fibres. It includes in every part longitudinal fibres which are the continuation of the anterior and lateral columns of the cord, together with arciform fibres and scattered ganglion-cells. Posteriorly there is a so-called raphe (*r*), due to the decussation of some of the fibres in the middle line.

The tegmental portion of the **medulla** contains the nuclei of the twelfth, eleventh, tenth, ninth, and part of the eighth cranial nerves (Figs. 248, 249), the olivary nucleus (Fig. 249 *o*), the accessory olivary nuclei (*oam*, *oal*), the nucleus of the funiculus gracilis (*ng*), the nucleus of the funiculus cuneatus (*nc*), and other nuclei. The restiform body (Fig. 248 *c*) also belongs to this region, through which pass fibres from the lateral cerebellar tract of the cord, from the olivary body, and from the formatio reticularis, to the cerebellum.

The tegmental portion of the **pons** contains the nuclei of the

fifth, sixth, seventh, and part of the eighth cranial nerves (Fig. 248). Fibres pass from the cerebellum into the formatio reticularis through the anterior peduncle of the cerebellum.

The tegmental portion of the **crura cerebri** lies beneath the aqueduct of Sylvius and is connected with the corpora quadrigemina and the anterior medullary velum. Beneath the aqueduct lies the nucleus of the third and fourth cranial nerves (Fig. 248). The formatio reticularis which lies to the ventral side of these nuclei contains (in addition to longitudinal bundles of fibres from the anterior and lateral columns of the cord) fibres from the corpora quadrigemina and anterior medullary velum, and from the cerebellum. The former proceed to the pons by way of the arcuate fibres, the latter by way of the anterior peduncles. The bundles from the cerebellum enclose in the part beneath the anterior corpora quadrigemina a reddish island of grey matter known as the red nucleus. Many of the fibres of these bundles terminate in this nucleus (GUDDEN), a few are seen to pass beyond it (FLECHSIG). These latter fibres pass to the exterior parts of the lenticular nucleus, to the optic thalamus, and to the cortex of the parietal lobe. The fibres thus proceeding to the cortex pass through the internal capsule and form the largest part of the sector of the corona radiata called by FLECHSIG the tegmental radiations (*Haubenstrahlung*).

The tegmental portion of the **inter-brain** (Art. 630) consists of the subthalamic region, and the grey matter forming the floor of the third ventricle and called the interpeduncular region, the latter being made up of the posterior perforated lamina (Fig. 247 *Spp*), the corpora albicantia (or mammillaria *Cm*), and the tuber cinereum *Tc*). The subthalamic region lies between the optic thalamus and the prolongation of the substantia nigra of the crura cerebri, and extends forwards to the anterior perforated lamina (*Lpa*). It is made up of a grey nucleus, the corpus subthalamicum (Fig. 245 *cs*) or body of Luys, and a dorsal layer of white matter connected with the optic thalamus and containing fibres proceeding to the corpus striatum from the red nucleus and superior cerebellar peduncles.

The **dorsal stratum** of the cerebral axis includes the cerebellum, the corpora quadrigemina, and the thalamus.

The **cerebellum** contains grey matter partly spread over the cortex, partly collected in the interior in masses known as the nucleus dentatus, nucleus emboliformis, nucleus globosus, and nucleus fastigii, respectively (STILLING). These nuclei are by means of the fibres of the white matter of the cerebellum connected not only with each other, but also (through the several cerebellar peduncles) with various nuclei and tracts already described in the tegmental and peduncular regions; they are thus in relation with the cord on the one hand and with the optic thalamus, lenticular nucleus, and cerebrum on the other.

The **quadrigeminal region** consists of two anterior and two

posterior quadrigeminal bodies enclosing grey nuclei, and the grey lamina which forms the roof or dorsal covering of the aqueduct of Sylvius. The posterior bodies are connected by means of the lower fillet with the ventral aspect of the tegmental region, and by the inferior brachium with the internal geniculate body, a grey nucleus beneath and contiguous to the optic thalamus. They are probably also in connexion with the optic nerves and the cortex cerebri. The anterior bodies are connected with the optic nerves, with the tegmental region (through the upper fillet) and with the cortex cerebri.

The **thalamus** consists of the optic thalamus in the narrower sense of the term, of the grey matter lining the cavity of the third ventricle, and of the external corpus geniculatum. The optic thalamus has extensive connexions with the cortex cerebri (these pass outwards chiefly through the internal capsule, but in part also beneath the lenticular nucleus), with the tegmental region, and also with the optic tract. The outer corpus geniculatum lying towards the outward extremity of the pulvinar or posterior tubercle of the thalamus is of a dark-grey tint; it is a centre for the nerves of vision.

The cerebral axis contains no elements subserving any psychical function; the **functions** of its centres are partly involuntary or **automatic**, partly **reflex**.

Thus the medulla contains the reflex-centres for closure of the eyelids, for coughing, sneezing, sucking, and so on, together with centres which co-ordinate certain subordinate reflexes within the spinal cord. It also contains the centres which control respiration and the movements of the heart, the vaso-motor centre, and a region which when stimulated gives rise to general convulsions.

Stimulation of the pons causes spasmodic movements and pain; its destruction is followed by paralysis—motor, sensory, and vaso-motor. In the cerebellum and quadrigeminal bodies lie centres for co-ordinating locomotion and other muscular movements.

The functions of the thalamus and of the nuclei of the pons are not certainly known.

References:—TÜRCK, *Wiener Sitzungsber.* VI; DUVAL, *Journ. de l'anat. et de la physiol.* 1876, '77, '78, '79 and '80, *Gaz. méd. de Paris* 14, 1880; GIERKE, *Pflüger's Arch.* vol. 7 (1873); LAURA, *Memorie della real. acad. di Torino* 1878-79; WERNICKE, *Arch. f. Psych.* VII (1877); STILLING, *Unters. üb. d. Bau d. klein. Gehirns d. Menschen* I–III Cassel 1864—1870; FOREL, *Wiener Sitzungsber.* LXVI (1872), *Arch. f. Psych.* VII (1877); GUDDEN, *Corresp. f. Schweiz. Aerzte* II, *Arch. f. Psych.* II, V, *Naturforscherversammlung in Cassel* 1882; SCHWALBE, *Lehrb. d. Neurologie* Erlangen 1881; WERNICKE, *Lehrb. d. Gehirnkrankh.* 1881; FLECHSIG, *Ueb. Systemerkrank. d. Ruckenmarks* 1872, *Plan d. menschlichen Gehirnes* Leipzig 1883; CHARCOT, *Progrès méd.* 1879, *Localisation of cerebral and spinal diseases* London (New Syd. Soc.) 1883; ROSS, *Diseases of the nervous system* London 1883; LANDOIS, *Physiol. d. Menschen* Leipzig 1881; LANDOIS and STIRLING, *Human Physiology* London 1886; HERMANN, *Grundriss d. Physiol. d. Menschen* Berlin 1882; FERRIER, *The functions of the brain* London 1886; MONAKOW, *Arch. f. Psych.* XIV (1883);

ERB, *Ziemssen's Cyclopaedia* XIII; HILL, *Plan of the central nervous system* Cambridge 1885.

628. The central nervous system is enclosed in three fibrous envelopes or **meninges**—the dura mater, the arachnoid, and the pia mater.

The **dura mater** is a tough vascular membrane traversed by numerous lymphatics. In the cranium it is closely adherent to the bones of the skull: in the vertebral canal it splits into two laminae, the exterior forming the periosteum of the bony walls, the interior loosely surrounding the cord. It gives off a fibrous dural sheath to each of the nerves.

The **arachnoid** is a delicate non-vascular membrane everywhere closely applied to the dura mater, with only a capillary space intervening (the subdural space). This interstice is a lymph-space, which communicates with the adjacent lymphatics of the neck, nose, eye, and dura mater, and also with the venous sinuses in the latter (by means of the arachnoidal villi or pacchionian bodies): it is continuous with the subdural spaces within the dural sheaths of the nerves (KEY and RETZIUS), and is everywhere clothed with endothelium

The **pia mater** is a delicate highly vascular membrane which closely invests the brain and spinal cord. Between the pia mater and the arachnoid lies the subarachnoid space, whose dimensions vary greatly with the varying relations of the two membranes. It is everywhere traversed by delicate fibrous trabeculae or membranous expansions covered with endothelium (the **subarachnoid tissue**), and contains a liquid known as the cerebrospinal or subarachnoid fluid. The space is narrow over the gyri and wider over the sulci. It is wider still in the spine, and at certain places within the skull where it expands into regular sinuses or **cisterns**. Such for example occur between the dorsal surface of the medulla and the posterior part of the cerebellum, in the interpeduncular space (between the crura cerebri), in front of the optic chiasma, between the under surface of the cerebellar hemispheres and the lateral portions of the medulla, on both sides of the transverse fissure, and at the lower ends of the sylvian fissures.

The pia mater and subarachnoid tissue send processes into the cleft between the cerebellum and medulla, and into that between the upper surface of the cerebellum and corpora quadrigemina and the under surface of the cerebrum: these processes are continued into the interior of the adjoining ventricles and form the telae choroideae and **choroid plexuses**. Here also are the chief channels of communication between the subarachnoid cisterns and the cavities of the fourth (foramen of Magendie) and third ventricles.

The subarachnoid spaces thus communicate not only with each other but also with the cerebral ventricles. The spaces also communicate with the lymphatics of the head, with the lymph-spaces of the nerves as they take their exit, and with the dural

venous sinuses. Communication with the lymphatics of the neck and of the nerves takes place by means of processes of the pia mater (**pial sheaths**) which surround the vessels and nerves as they enter or leave. With the dural sinuses communication takes place by means of the pacchionian bodies, which are rounded excrescences of arachnoid and subarachnoid tissue penetrating into the dura, and separated only by a thin dural film from the venous blood in the sinuses.

The cerebral **blood-vessels** before they enter the brain all pass through the subarachnoid space and the pia mater, and carry with them a pial sheath. They are thus even within the brain surrounded by lymph-spaces, which are known as adventitial **lymph-sheaths** (VIRCHOW, ROBIN) and communicate freely with the pial spaces. The central nervous system is thus not only surrounded on all sides by lymph-spaces but also traversed in all directions by lymph-channels, and its blood-vessels all lie in lymph-sheaths.

The arteries of the brain are divided into basal or ganglionic and cortical (HEUBNER, DURET). The former are terminal arteries, ramifying in the basal ganglia and the internal capsule; the latter anastomose freely within the pia mater. The choroid plexuses also carry vessels into the interior of the ventricles; they may be described as villous processes covered with polygonal epithelium and containing a multitude of capillary loops of large size.

The vessels of the cord pass into the nerve-substance partly from the periphery, partly by way of the longitudinal fissures.

Many authors (such as HIS, ROTH, etc.) affirm that circumvascular and epicerebral lymph-spaces exist outside the adventitia of the vessels and beneath the pia mater, and that these spaces are traversed by fine trabecula emerging from the brain-substance and passing into the adventitia of the vessels. ZIEGLER, with BOLL, GOLGI, and others, makes out that these spaces, when they are met with at all, are due to artificial causes such as the hardening of the brain in solutions of chromic acid and so on.

References on the membranes and vessels of the brain and cord:—HIS, *Zeitschrift f. wissenschaft. Zool.* XV (1864); ROBIN, *Journ. de physiol.* II (1859); ROTH, *Virch. Arch.* vol. 46; AXEL KEY and G. RETZIUS, *Studien in d. Anatomie d. Nervensystemes u. d. Bindegewebes* I and II Stockholm 1875–76; SCHWALBE, *Med. Centralb.* 30, 1869, *Arch. f. mikrosk. Anat.* VI (1870), *Lehrb. d. Neurol.* 1881; SÉE, *Revue mensuelle* II (1878); RIEDEL, *Arch. f. mikrosk. Anat.* XI (1875); OBERSTEINER, *Wiener Sitzungsber.* LXI (1870); GOLGI, *Rivista clinica* Nov. 1871; BOLL, *Arch. f. Psych.* IV (1873); LOWE, *ibid.* VII; HEUBNER, *Cent. f. med. Wiss.* 1872, *Die luetische Erkrankung d. Hirnarterien* Leipzig 1874; DURET, *Recherches anatomiques sur la circulation de l'encéphale*, *Arch. de physiol.* 1874; ADAMKIEWICZ, *Die Blutgefasse d. menschlichen Rückenmarkes*, *Wiener Sitzungsber.* LXXXIV, LXXXV (1881–82), *Trans. internat. med. Congress* I London 1881; MOSSO, *Ueber d. Kreislauf d. Blutes im menschlichen Gehirn* Leipzig 1881; CHARCOT, *Leçons sur les localisations* Paris 1876, trans. by HADDEN (New Syd. Soc.) London 1883; KLEIN and NOBLE SMITH, *Atlas of Histology* London 1880; ROSS, *Brain* III (1880), *Diseases of the nervous system* London 1883.

629. The central nervous system is composed of tissue the normal performance of whose functions depends greatly on the normal circulation of healthy blood within it.

A brief obstruction to the inflow or outflow of blood is sufficient to give rise to grave disorder of the nervous functions, and in like manner an excess of carbonic acid or a deficiency of oxygen may give rise to serious irritation or paralysis of particular parts. When such disturbances of circulation or nutrition reach a certain degree of gravity they are apt to be followed by transient or permanent degenerative changes in the nervous structures. Such **degenerations** form the basis of an important group of diseases of the brain and cord.

In many acute febrile disorders disturbances of the cerebral functions is a symptom. This disturbance is due partly to overheating of the tissues, partly to disorder of the circulation, partly to impurities and changes in the composition of the blood. The fact that permanent lesions of the brain and cord are comparatively rare sequelae of such fevers shows that nerve-substance has a remarkable power of resistance to a number of injurious agencies, that in other words the brain and cord like other organs can be permanently injured only by agencies of particular kinds. That these agencies have about them something special is made likely by the fact—that many **poisons** when introduced into the blood exert a marked specific action on the nerve-cells and nerve-fibres, while others have no action whatever on these structures.

Every-day experience shows that personal **predisposition** plays an unusually important part in the genesis of central nervous diseases. This predisposition is usually inherited, seldom acquired. According to WESTPHAL in 50 per cent. of insane patients the occurrence of disease of the central nervous system in some blood-relation of the ascending line can be demonstrated. It is not actual disease which is thus transmitted from parent to child but only a liability to disease, a lack of resisting-power, in consequence of which influences (unable in a normal individual to produce any abiding disturbance) are capable of setting up disorders of function and often alterations of structure. The morbid influences may be of any kind, and may reach the central nervous system either by way of the circulation or as morbid stimuli by way of the nerves.

Predisposition to nervous disease is usually a matter beyond the scope of anatomical research, but cases do occur in which the inherited or at least congenital pathological condition manifests itself as a defect of development in the central nervous system. In other words **malformations** of the brain are very commonly associated with defective brain-function, and constitute a predisposition to further nervous disease.

Inherited and acquired predisposition is of special importance in connexion with diseases of the central nervous system that are chronic. It has little to do with the genesis of acute and particularly of inflammatory disorders, which are as a rule set up by irritant matters reaching the nerve-tissues through the **circulation**.

A common source of brain-affections, especially of the inflammatory kind, is disease of the adjacent structures, such as the base of the skull, the petrous bone, the skull-cap, the nose and its cavities, etc. The contents of the cranium and vertebral canal are in communication by means of blood-vessels and lymphatics with the surrounding parts, and thus inflammatory mischief may invade the brain and cord not only by **direct extension** but also through the blood and lymph.

Lastly, both brain and cord are much exposed to injury by **traumatic violence** of the most various kinds, and in consequence undergo a great variety of morbid changes which are often extremely grave.

CHAPTER XCII.

MALFORMATIONS OF THE BRAIN AND SPINAL CORD.

630. The cerebrospinal system takes its origin from the **medullary tube** or canal formed by the infolding of the epiblast along the medullary groove. The cells lining the lumen of this tube become the ciliated epithelium of the central canal and ventricles of the cord and brain, the remaining cells develope into the ganglion-cells and their processes.

The rudiment of the brain appears as three primary **cerebral vesicles,** which are simple dilatations of the anterior end of the medullary tube. The first and third vesicles each divide into two, and thus five vesicles are produced from whose walls the various parts of the brain are developed. From the first vesicle (**fore-brain** or prosencephalon) are formed the cerebral hemispheres, the corpora striata, the lenticular nucleus, the corpus callosum, and the fornix: from the others, which are known as the **inter-brain** (thalamencephalon), **mid-brain** (mesencephalon), **hind-brain** (epencephalon), and **after-brain** (metencephalon), are derived the various parts of the cerebral axis and its dorsal stratum.

In the region of the after-brain (or medulla oblongata) the medullary tube never completely closes, so that here a communication with the interior of the tube remains open. The development of the fore-brain proceeds rapidly, and the cerebral hemispheres thus produced in the human adult ultimately overlie almost all the rest of the brain.

If the formation of the medullary tube from the medullary groove of the embryo is for any reason interfered with, or if the dorsal wall of the tube is imperfectly formed or destroyed, the cerebrum and part of the cerebral axis remain undeveloped, and we have the condition known as **total anencephalia.** According to LEBEDEFF the same result may take place if the cranial flexure of the embryo be abnormally sharp. G. ST HILAIRE, FORSTER, and PANUM think that the absence of the brain is chiefly owing to an excessive accumulation of liquid in the medullary tube. DARESTE and PERLS on the other hand are of opinion that anencephalia is due to an abnormal pressure of the head-fold of the amnion on the

cephalic end of the embryo (Art. 7). When for any reason some part of the medullary tube is destroyed or hindered in its development the growth of the lateral medullary plates does not entirely cease (LEBEDEFF); they enlarge and form a number of folds buried in the substance of the mesoblast, and becoming partially abstricted take the form of irregular cysts and cavities. When the liquor amnii makes its appearance the exposed medullary plates are usually much damaged; the underlying mesoblast developes at the same time into the cerebral membranes, and the result is that instead of a brain we have covering the base of the skull a mass of vascular connective tissue containing cystic cavities and marrow-like remnants of brain-substance. As the dorsal wall of the medullary tube was defective or absent, the cranial vault is more or less defective or absent, and the anencephalia is thus associated with conditions known as **acrania, hemicephalus**, or **cranioschisis** (Art. 7).

When the development of the brain is only in part interfered with, or when parts only of the rudimental structures have been destroyed in an early stage, the result is some partial deficiency which we may appropriately call **partial anencephalia.**

The situation, size, and extent of such deficiencies may of course vary greatly in different cases, and give rise to a great variety of brain-deformities. If the skull is closed (and in these cases it usually is closed) the space left vacant by the ill-developed brain becomes filled with liquid, which gathers either in the subarachnoid tissue outside the existing brain-mass, or within it in one of its ventricles, or in both places together. The latter forms have been described by CRUVEILHIER as hydrocephalic anencephalia.

Cases of anencephalia also occur in which more or less important parts of the base of the brain (*e.g.* the basal ganglia) are properly developed, and others in which while one hemisphere is developed (though perhaps malformed) the other hemisphere is wanting. The cranial vault in such cases may either be entire, defective, or distended as in hydrocephalus (Art. 631). When the vault is closed the fragments of brain-substance are shut off from the space filled with liquid by a fibrous partition representing some of the cerebral membranes. If the defect of development has mainly affected the anterior part of the fore-brain we have the malformation known as **synophthalmia** or **cyclopia,** and **arhinencephalia** (KUNDRAT). In the latter form the nose is undeveloped, in the former the eyes (Art. 7). The nose sometimes takes the form of a snout-like projection (ethmocephalia), sometimes it is a mere stunted remnant (cebocephalia); in other cases again there is a median fissure of the upper lip and of the septum of the nose, or a single or double lateral hare-lip and cleft-palate. In the slightest variety of the malformation the face is normal, the brow alone being narrow and tapering.

In both synophthalmia and arhinencephalia the cerebrum is

more or less malformed: in the gravest variety the brain is represented by a mere pointed vesicle. In slighter cases particular parts are wanting, such as the olfactory nerve and lobe, the corpus callosum, some of the convolutions, etc. The quadrigeminal bodies are often coalescent. The optic chiasma and tracts are sometimes absent, sometimes normal.

Between such grave defects and the slightest, involving perhaps merely a portion of one convolution, all intermediate varieties of malformation are met with.

The slightest kind of defect occurring on the outer surface of the brain takes the form of shallow depressions or excavations of the gyri, the hollows being lined with pia mater. When entire gyri or considerable portions of gyri are wanting the defects appear as open clefts or funnel-shaped pits or perforations extending sometimes to the walls or even into the interior of the ventricles. This condition has been called **porencephalia** (HESCHL). The cavities are lined with pia mater, which is discontinuous only where they communicate with the cavity of the ventricle. The spaces thus formed are in general filled up with liquid collected in the subarachnoid tissue, and are bridged over and enclosed by the arachnoid membrane. In other cases the adjacent convolutions are pressed together over the gap, which then takes the form of a deep cleft or interstice.

When the defect is larger (involving it may be a lobe or more) similar conditions obtain. The neighbouring ventricles are seldom of normal size, being usually more or less dilated or showing local sacculations opposite to the missing regions. The surrounding convolutions tend to be arranged radially round the gap as if puckered and drawn into it. The remainder of the brain may be quite normal, but at times the convolutions are abnormally arranged or ill-developed. The basal ganglia on the side of the dilated ventricles are flattened. The cranium is either normal or somewhat asymmetrical. When the brain is imperfect the skull is usually small, but in marked ventricular hydrocephalus it is enlarged.

Another variety of partial anencephalia is the absence of some of the deeper structures and especially of the basal ganglia. Thus the corpus callosum and fornix may be wanting or imperfect, and so likewise may the grey commissure of the third ventricle, the corpora albicantia, the corpora quadrigemina, etc. When the corpus callosum is absent the gyrus fornicatus and gyrus hippocampi are usually absent also, and some of the other convolutions are frequently irregular in form or arrangement.

The causation of partial anencephalia is not the same in all cases. Porencephalia is probably in many cases due to intra-uterine disorders of circulation, haemorrhages, and inflammations, by which portions of the brain already developed are damaged or destroyed. In favour of this view is the fact—that the brain-substance and the

membranes in the neighbourhood of the defect often show changes similar to those which in later life are known to follow upon submeningeal anaemic and inflammatory softening (Art. 642). Pressure from without or a blow on the cranium may in some cases bring about a like result. In others internal or ventricular hydrocephalus (Art. 631) may disturb the circulation of the part and lead to its wasting or disappearance. When the convolutions about the defect are normal it is probable that the destruction took place at a time when the brain was fairly developed, say not later than the fifth month. Obvious disturbance of the configuration of the brain would imply an earlier date. Occasionally such local defects must be due to actual failure of development, or **agenesis** as it might be called. Deficiencies in the deeper parts of the brain are usually unaccompanied by any signs of destructive disease; they would therefore seem to be due to primary failure of development.

The condition of the cord corresponding to anencephalia is called **amyelia**. Most frequently the two go together, and are accompanied by defects of the vertebral arches and of the meninges and integuments. A cleft thus extends from the opening in the cranium down to the cervical, dorsal, or it may be to the sacral region (**rhachischisis**). Clefts of the dorsal or lumbar spine alone, extending through the skin, are more rare. Where the vertebral arches are absent the cord is also wanting, so that the vertebral bodies are covered only by membranes. Such defects are due either to some sharp flexure of the embryo, to imperfect separation of the medullary plate from the superficial or epidermic epiblast, or to dropsical distension of the medullary tube. Partial defects of the cord are very rare when the spinal canal is closed. On the other hand ADAMKIEWICZ states that in 80 persons out of 100 some of the 31 pairs of roots of the spinal nerves will exhibit more or less marked defects, especially in the anterior roots. Slight asymmetry of the cord, chiefly in the decussation of the pyramids in the medulla, is an extremely common phenomenon.

The term **porencephalia** (or porencephalus) is used in different senses by different writers, some confining it to congenital defects, others applying it to those which are acquired after birth. Many apply it only to small and localised defects, others extend it so that it might imply the absence of an entire cerebral hemisphere. It seems better to limit its application to localised defects that are congenital or at least acquired in early infancy.

When in total or partial anencephalia the motor centres and tracts are wanting, the pyramidal tracts and columns of the cord do not develope (FLECHSIG). And in partial failure of development (agenesis) of the brain FICK observes that the pyramidal tracts are imperfectly differentiated, the medullary sheath of the fibres being ill-developed.

References on anencephalia and amyelia:—DARESTE, *Recherches sur la production des monstruosités* Paris 1877; PERLS, *Allg. Path.* II 1879; LEBEDEFF, *Virch. Arch.* vol. 86; FÖRSTER, *Missbildungen d. Menschen* Jena 1865, *Handb. d. path. Anat.* 1865; HESCHL, *Prager Vierteljahrsschrift* 1859, '61, '68, *Jahrb. f. Kinderheilk.* XV, *Arch. d. Gesell. f. Aerzte in Wien* 1878; KUNDRAT, *Die Porencephalie* Graz 1882, *Die Arhinencephalie* Graz 1882; KLEBS, *Ueber Hydro- u. Mikroanencephalie, Oesterreich. Jahrb. f. Pädiatrik* 1876; SCHULE,

Zeitschr. f. Psych. XXVI; BINSWANGER, *Virch. Arch.* vol. 87; WILLE, *Arch. f. Psych.* X (1880); CHIARI, *Jahrb. f. Kinderheilk.* XV; AHLFELD, *Die Missbildungen d. Menschen* II (1882); KIRCHHOFF, *Arch. f. Psych.* XIII (1882); SPERLING, *Virch. Arch.* vol. 91; RIBBERT, *ibid.* vol. 93; DE LA CROIX, *ibid.* vol. 97; HEYDENREICH, *ibid.* vol. 100; ROSS, *Diseases of the nervous system* II London 1883; CLELAND, *Journ. of Anat. and Physiol.* XII, XVII.

On absence of the corpus callosum:—PAGET, *Med. chir. Trans.* XXIX (1846); SANDER, *Arch. f. Psych.* I (1868); JOLLY, *Zeits. f. ration. Med.* XXXIV (1869); HUPPERT, *Arch. d. Heilk.* 1871; MALINVERNI, *Gaz. delle cliniche* 1874, *London Med. Record* 1874.

On rhachischisis see Art. 632.

On defects of the spinal cord:—FROISIER, *Arch. de physiol.* 1872; ADAMKIEWICZ, *Virch. Arch.* vol. 88; LEYDEN, *Klinik d. Rückenmarkskr.* I (1874); FLECHSIG, *Ueb. Systemerkrank.* Leipzig 1878; PICK, *Prager med. Woch.* 1880; ROSS, *Brain* V (1882). See also Arts. 632, 637.

631. An increased quantity of liquid may collect in the medullary tube or in the ventricles of the brain at any stage of foetal development or after birth. If the accumulation take place very early the development of the brain may be seriously interfered with (Art. 630), its cavities are distended, and the resulting condition is described as **congenital internal hydrocephalus**. The liquid most frequently collects in the lateral ventricles, the other cavities being rarely involved. The affection is usually bilateral, though it is sometimes confined to one side.

At the time of birth the dilatation is sometimes slight, sometimes already considerable, the cranium being visibly enlarged. It often increases steadily until it reaches an enormous size, the skin is stretched and thin, and the subcutaneous veins show through its semi-transparent texture. The cranial bones become widely separated, and even though they grow to an abnormal size they do not keep pace with the distension of the whole. The fontanelles become larger and the sutures wider, and at times accessory bones make their appearance in the fibrous tissues that bridge over these spaces.

When death occurs the dura mater and the underlying membranes are found stretched to the utmost, the convolutions flattened and depressed, the sulci effaced. The brain-substance forms a mere capsule round the dilated ventricles, the thickness on the convexity of the hemispheres being sometimes not more than a few millimetres.

The liquid in the ventricles is clear and colourless or pale-yellow. The ependyma is stretched but not otherwise altered. The basal ganglia are flattened out. The fourth ventricle and the cerebellum are usually unaltered, though the former is sometimes partially dilated.

The above is the usual condition of things: in some instances however the distension of the lateral ventricles is less extreme, or it is confined to one or a part of one only. Thus one ventricle may be so distended that it is bounded only by a thin film of membrane, while the other is undilated. In like manner the

fourth ventricle alone may be dilated. In these cases the general dilatation of the cranium does not take place, the enlargement of the ventricle being accompanied by atrophy of the rest of the brain.

Extreme hydrocephalus terminates fatally. The less-marked forms are compatible with continued life. But if the dilatation is at all considerable the compressed parts of the brain undergo partial atrophy, that is to say disappearance and calcification of nerve-cells and nerve-fibres.

Great dilatation of the fourth ventricle is often accompanied by wasting of the cerebellum, pons, and medulla, or by actual disappearance of some parts of them.

Slight congenital hydrocephalus, especially if it does not increase after birth, is not altogether incompatible with a subsequent normal development of the brain.

The cause of congenital hydrocephalus is far from clear. Often no morbid changes of an inflammatory kind are to be seen, and it is usually hard to demonstrate any impediment to the outflow of venous blood from the cranium. Occasionally however thickenings of the meninges or of the plexuses are discovered, and these appear to indicate antecedent inflammation. The presence of pus-corpuscles in the hydrocephalic liquid is a surer indication. Probably in many cases the cause is to be found in some abnormal closure of the communications between the ventricular cavities and the subarachnoid spaces. These have at least in some cases been found obstructed (HUGUENIN, ZIEGLER). As moreover in such cases the pia mater over the transverse fissures at the base has been denser than usual, it is possible that the circulation in the veins of Galen was impeded. In certain instances hydrocephalus seems to be a result of rickets or of syphilis. When the skull-cavity is not dilated and the brain not compressed, while the ventricle is dilated, it appears natural to assume that the cause of the latter dilatation is the arrested development (aplasia) of the brain. The condition has been described as a dropsy *ex vacuo*.

In unilateral hydrocephalus the foramen of Monro has been found closed.

An abnormal collection of liquid in the subarachnoid tissue is called **meningeal hydrocephalus**. Of the congenital varieties some are simply due to general failure of development (agenesis, Arts. 630, 633), to local aplasia, or to some disturbance of the growth of the brain: the liquid in the meshes of the subarachnoid tissue fills the space which should have been occupied by the brain. The skull is not dilated.

In another form however the accumulation of liquid is not preceded by cerebral atrophy or aplasia, and then the brain-substance becomes compressed and the skull more or less dilated.

When the brain developes abnormally and its growth is hindered, liquid may collect in the subdural space and so fill out

the cranial cavity. This condition is known as **external hydrocephalus** (VIRCHOW).

In Art. 7 we mentioned that when minor deficiencies occur in the bony walls of the skull the cranial contents protrude, and forcing out the dura mater, the cranial aponeurosis, and the scalp take the form of a rounded tumour. Such a tumour is called a **cephalocele** or **hernia cerebri**. Three forms are distinguished according to their contents. The commonest is hydrencephalocele, in which the tumour contains a sacculation of a ventricle covered with brain-substance. Encephalocele and meningocele are much rarer: in the former brain-substance and pia mater only, and in the latter the pia mater and arachnoid distended with liquid, protrude into the dural sac.

The cause of hydrencephalocele is probably an antecedent hydrocephalus. In encephalocele and meningocele there is probably some local weakness of the membranes or defect in the ossification of the cranium (ACKERMANN); in some cases the condition may be due to adhesions between the meninges and the amnion (ST HILAIRE).

The commonest seat of cephalocele is at the lower end of the frontal suture (*hernia sincipitalis*), and about the squamous part of the occipital bone (*hernia occipitalis*). More rarely it occurs about the anterior fontanelle, the squamosal suture, the base of the skull, the orbital fissure, etc. It may continue to grow after birth.

References on hydrocephalus and cephalocele:—HUGUENIN, *Ziemssen's Cyclopaedia* XII; VIRCHOW, *Virch. Arch.* vol. 27; GUNZ, *Jahrb. d. Kinderheilk.* V (1862); KOLLER and SCHMIDT, *ibid.* VI (1863); HANEL, *ibid.* (new series) I; AMYOT, *Med. Times* 1, 1869; DICKINSON, *Lancet* 2, 1870; BUTTENWIESER, *D. Arch. f. klin. Med.* X (1872); PAPP and NEUPAUER, *Jahrb. f. Kinderheilk.* (new series) VII; MAENNEL, *Jahrb. f. Pädiatrik* 1876; STEFFEN, *Gerhardt's Handb. d. Kinderkr.* V; VIRCHOW, *Krankh. Geschwülste* I; S. TALKO, *Virch. Arch.* vol. 50; HARRIS, *Obstetr. Trans.* VI; HENOCH, *Charité-Annalen* IV; BIZZOLI, *Bullet. d. scien. med. d. Bologna* 1872; RAAB, *Wien. med. Woch.* 1876; J. F. WEST, *Jahrb. f. Kinderheilk.* IX (1876); BAUER, *ibid.* XI; MUHR, *Arch. f. Psych.* VIII; HEWETT, *St Geo. Hosp. Rep.* 1873; HEINEKE, *Pitha u. Billroth's Handb.* III; DEMME, *Jahresber. d. Jenner. Kinderspitals* Bern 1876; SZYMANOWSKI, *Langenbeck's Arch.* VI; SPRING, *Monographie de la hernie du cerveau* Brussels 1853; G. REALI, *Ueb. d. Behand. d. angeb. Schädel- u. Rückgratsbrüche* In. Diss. Zürich 1874; ACKERMANN, *Die Schädeldifformität bei d. Encephalocele congenita* Halle 1882.

632. Corresponding to internal hydrocephalus we have a congested collection of liquid in the central canal of the cord: this is termed **internal hydromyelia** or hydrorrhachis. The canal is dilated either in parts or throughout its whole length, and the substance of the cord is accordingly thinned out. Partial dilatations are fusiform, cylindrical, or sacculate. Cases occur in which comparatively large cavities lined with cylindrical epithelium are found in the region of the posterior columns, the columns themselves being ill-developed (Arts. 637 and 650).

When the dilatation of the canal is slight the development of the cord may be normal, but where the dilatation is more marked there is always some thinning of the nerve-substance, and the posterior columns especially are apt to suffer. Extreme localised or cystic dilatation, such as in the cervical region frequently accompanies hydrencephalocele, sometimes leads to actual discontinuity of the cord.

Another variety allied to the last takes the form of a cystic tumour-like growth protruding through the walls of the vertebral canal and appearing under the skin of the back or on the lateral or anterior aspect of the spinal column. This is known as **myelo-meningocele** or **spina bifida** (Art. 7).

Lumbo-sacral myelomeningocele is the commonest form. The tumour appears in the mid-dorsal line immediately above the sacrum or on the lumbar spine. It is covered with smooth or shining and sometimes thinned integument, and is of the size of a walnut or a little larger. The inner surface of the cyst is sometimes smooth, sometimes rough with outgrowths from the walls: on the upper and ventral aspect the cord is seen. It is elongated and, it may be, somewhat swollen, or attached by a broad base to the inner surface, or it is lost immediately after it enters, breaking up into a number of strands which run in the wall of the cyst.

In rare cases the cyst at birth is open, or there may be no cyst properly speaking but merely a hole in the skin surrounded by a raised border and leading by a funnel-like passage directly into the central canal of the cord.

The wall of the cyst or sack is formed chiefly of the sacculated dura mater, and the vertebral arches and spinous processes are always absent at its neck. Hence the name—sacral spina bifida—sometimes given to the malformation.

Dorsal and cervical myelomeningoceles are much more rare, and usually smaller. The dura bulges slightly through the gap in the series of vertebral arches, while a conical or cylindrical process from the posterior aspect of the cord enters and becomes adherent to the wall of the sack The process contains both grey and white matter, and sometimes encloses also a saccular dilatation of the central canal.

Lastly there is a form of cystic protrusion occurring in the sacral region and involving chiefly or only the membranes of the cord: it is hence described as **spinal meningocele**. A local accumulation of fluid takes place at the lower part of the subarachnoid space: the dura and the adherent arachnoid are then forced through some normal opening (such as that between two arches, an intervertebral foramen, or the lumbo-sacral hiatus) or through an abnormal one due to absence of an arch or part of a vertebral body, and thus form a protuberance on the posterior, lateral, or anterior aspect of the spine. If the liquid continues to

accumulate the cyst may attain a large size. The *filum terminale* and some of the spinal nerves connect it with the cord.

It seems at first natural to suppose that the three varieties of malformation just described are due simply to morbid accumulation of liquid in the central canal, in other words to hydromyelia combined with a local meningeal dropsy: this view has been taken by many authors (FORSTER, AHLFELD, and others). The anatomical characters presented by a myelomeningocele are however inconsistent with the supposition, and make it more probable that during the evolution of the central nervous system the medullary tube was imperfectly differentiated off from the surface or epidermic epiblast (RANKE, VIRCHOW, TOURNEUX, MARTIN, MARCHAND, etc.). This at least explains the fact that the cord so frequently passes out with the sack, and that the central canal sometimes opens freely into its cavity. When the cleft in the integument becomes closed over and the membranes of the cord are developed, liquid collects partly in the subarachnoid space and partly in the lower end of the central canal. It is however a question whether in some cases hydromyelia alone may not lead to myelomeningocele.

Nothing certain is known as to the causation of meningocele. Perhaps here too the malformation depends on the imperfect differentiation of the cord-substance from the epidermis.

References:—VIRCHOW, *Virch. Arch.* vol. 27, *Krankh. Geschwülste* I; LEYDEN, *Virch. Arch.* vol. 68, *Klinik d. Rückenmarkskrankheiten* I Berlin 1874; CRUVEILHIER, *Anat. pathol.* Paris 1824–1842; HILTON, *Lancet* 2, 1860; Discussion, *Med. Times and Gaz.* 2, 1858; RINDFLEISCH, *Virch. Arch.* vols. 19, 27; FÖRSTER, *Missbild d. Menschen* Jena 1865; BRAUNE, *Die Doppelbildungen und die angeb. Geschwülste d. Kreuzbeingegend* Leipzig 1862; FLEISCHMANN, *Jahrb. f. Kinderheilk.* (new series) V; J. RANKE, *ibid.* XII (1878); DARESTE, *Product. artific. d. monstruosités* Paris 1877; TOURNEUX and MARTIN, *Journ. de l'anat.* 1881; W. KOCH, *Mittheil. üb. Fragen d. wiss. Medicin* I Cassel 1881; AHLFELD, *Die Missbild. d. Menschen* II Leipzig 1882; MARCHAND, *Arch. f. Gynäk.* XVII (1881), Art. *Spina bifida* in *Eulenburg's Realencyclop.* 1882; DEMME, *Berichte ub. d. Kinderspitals* Berne 1883; ERB, *Ziemssen's Cyclop.* XIII; HOLMES, *Syst. of surgery* III London 1883 (with references); HUMPHRY, *Lancet* 1, 1885, *Journ. of Anat. and Physiol.* XIX, XX (1885–1886); CLELAND, *ibid.* XVII; Report, *Trans. Clin. Soc.* XVIII 1885; VON RECKLINGHAUSEN, *Virch. Arch.* vol. 105.

633. Particular parts of the central nervous system are frequently ill-developed, and in consequence remain after birth abnormally small. The cerebrum is naturally the part which has attracted most attention in this respect. When it fails to reach the minimum size met with in healthy persons the condition is spoken of as **micrencephalia**: when the cranium as a whole is likewise abnormally small we have **microcephalia**.

The average weight of the adult male cerebrum is 1375 grammes, that of the female 1245. The minimum weight for the male is 960 grammes, for the female 880; the maximum for the male 1800, and for the female 1600 grammes. The brain of a

new-born infant is about 385 grammes, that of a two-year-old child 1173 grammes. The brain-weight of an infant is therefore very large relatively to its body-weight, the proportion being about 14 : 100, while that of an adult is only 2·37 : 100 (VIERORDT).

Micrencephalia is usually apparent even at birth, but it becomes more obvious as the child developes: while the back part of the cranium remains stationary (microcephalia) the face grows apace and the disproportion becomes very marked. This aplasia of the brain is sometimes greater in one part than another, the anterior, lateral, or posterior region being in different cases the most stunted. As a rule however all parts are abnormally small. The gyri and sulci are generally ill-developed and abnormal in their arrangement. The subordinate or secondary sulci are usually the most defective, though cases occur in which some of the principal convolutions and fissures are entirely absent. The statistics of VOGT and JENSEN show that the weight of the brain in microcephalic patients may fall to one-third or one-fourth of the normal. The cerebellum and cerebral axis like the hemispheres are liable to be dwarfed, though they are usually less so than the latter.

C. VOGT thought that in micrencephalia we had an instance of atavism or reversion to an earlier developmental type in the *Primates*. The later researches of AEBY, JENSEN, KLEBS, FLESCH, VIRCHOW, BINSWANGER, and others have however shown that this view is untenable. Micrencephalia is an arrest or rather failure of development, an *agenesis*, due either to intrinsic causes or to injurious influences exerted on the embryo. It is accordingly very commonly found in association with other morbid alterations in the brain and other organs, and is partly a consequence and partly a concomitant of these.

Thus the micrencephalic patient may also exhibit porencephalia or ventricular hydrocephalus. Fibrous thickenings of the pia mater in some cases indicate antecedent inflammatory disorder. Often too there is some malformation of the extremities due to some injurious intra-uterine pressure; and premature synostosis of the cranial sutures, synchondrosis of the basal bones, and coalescence or cohesion of the hemispheres are also not uncommon. Of these changes some, *e.g.* porencephalia, meningeal inflammation, and premature synostosis, must occasionally be regarded not as mere concomitants of the defective cerebral development but as the primary changes which have led to it.

Less grave results of defective development are—abnormal smallness of particular lobes or gyri, and non-typical arrangement of the gyri associated with diminution (or occasionally increase) of their number. Thus in what has been called **microgyria** the surface of the hemispheres is thrown into a multitude of puckered creases or folds like those of a shirt-frill, the brain as a whole being usually malformed. Very frequently too in brains otherwise

normal in size the arrangement of the convolutions is so irregular that the typical furrows and fissures that serve as our landmarks can scarcely be recognised. In rare cases the separation of the hemispheres is incomplete (TURNER, *Journ. of Anat. and Physiol.* XII 1878).

Asymmetry of the hemispheres, affecting either the anterior or the posterior regions, is not infrequently observed. Smallness of the corpus callosum, the fornix, the thalami, the corpora striata, corpora albicantia, olivary bodies, corpora quadrigemina, etc. have also been described. The cerebellum may be no larger than a walnut, and in such cases the peduncles also are defective.

Abnormal smallness or shortness of the cord is known as **micromyelia**: the various tracts of the cord may likewise be imperfectly developed.

The causes of such local *ageneses* are sometimes undiscoverable; in other cases they are obviously connected with morbid conditions in other parts A certain amount of hydromyelia, for example, leads to defective development of the posterior columns. Absence of the central convolutions of the cortex results in the absence or degeneration of the pyramidal tracts. Congenital absence of the cerebellum is accompanied by absence of the superior peduncle and of the red nucleus (FLECHSIG).

The loss of any of the peripheral end-organs (Art. 649) results in partial or total atrophy of the corresponding centres in the central nervous system (GUDDEN).

The posterior columns have frequently been found ill-developed (KAHLER, PICK, JADERHOLM, SCHULTZE), and the like is true of some of the fibres in other tracts (KAHLER, PICK, WESTPHAL, FLECHSIG, FURSTNER). These forms of aplasia have a special interest, as they are probably the basis of a predisposition to disease of the cord

Heterotopia is a peculiar variety of malformation, in which masses of grey matter are found in abnormal situations. Such masses, in the form of grey nodules, are now and then met with in the ependyma of the ventricles (VIRCHOW, TUNGEL, E WAGNER, MESCHEDE) and in the subjacent white layer: they measure 1 to 10 mm. across and are sometimes very numerous. They have also been found in the middle of the centrum ovale (VIRCHOW, MESCHEDE), and somewhat resemble in structure the grey matter of the convolutions. Nodules of grey matter are also described (SIMON) as rising from the surface of the convolutions themselves in the form of little tumours. Heterotopia of grey matter also occurs in the cerebellum (PFLEGER), and lastly these misplaced masses have been found in the white tracts of the cerebral axis and of the cord (PICK, BRAMWELL, OSLER).

Most of those hitherto described contained ganglion-cells, but a few rather resembled the substantia gelatinosa of the cord. In the cord they are doubtless nothing more than isolated fragments

of the grey matter, which frequently in the same case itself shows signs of abnormal configuration or arrangement.

Hypertrophy of the brain is rare, though it has been observed in children and young persons: it may affect the whole or any part of the organ. It is due to excessive developmental growth, probably in the last resort arising from some abnormality in the primary rudiment of the brain. True acquired hypertrophy, not depending on congenital causes, has never been observed.

The brain and the cranium are more or less enlarged according to the extent of the hypertrophy. If the overgrowth takes place after the sutures of the skull have closed the bones in some places may be attenuated or absorbed under the continuous pressure. After death the gyri are usually found to be flattened, the ventricles narrow and appressed, and the brain-substance firm and condensed. We at present know little of the histological characters of the tissue: VIRCHOW states that the principal change is an increase of the neuroglia.

The cord in like manner is sometimes of abnormal size. Partial duplication has been met with in persons who were otherwise normally developed (LENHOSSECK, FURSTNER, ZACHER) or suffered from some malformation of the brain.

On microcephalia and malformation of the convolutions:—VIRCHOW, *Gesamm. Abhandl.* 1856; C. VOGT, *Arch. f. Anthropol.* II (1867); AEBY, *ibid.* VI, VII (1874), *Ueb. d. Verhaltniss d. Mikrocephalie z. Atavismus* Stuttgart 1878, *Virch. Arch.* vol. 77; ROHON, *Arbeit. a d. zool. Inst. zu Wien* II; WILLE, *Arch. f. Psych.* X; FLESCH, *Verhandl. d. phys.-med. Gesell. zu Wurzburg* VIII (1874), *Festschr. z. Jubil. d. Universitat Wurzburg* 1882; VIRCHOW, *Berl. klin. Woch.* 1877, *Verhandl. d. Berlin. anthrop. Gesell.* 1878; JENSEN, *Arch. f. Psych.* X; HADLICH, *ibid.*; SANDER, *ibid.* I (1870); KLEBS, *Sitzungsber. d. phys.-med. Gesell. zu Würzburg* 1873; SHUTTLEWORTH, *Journ. of mental science* Oct. 1878; BINSWANGER, *Virch. Arch.* vol. 87; RETZIUS, *Hofmann und Schwalbe's Jahresber.* 1878; CHIARI, *Jahrb. f. Kinderheilk.* XIV.

On aplasia of the cerebellum and cord:—MEYNERT, *Med. Jahrb. d. Gesell. f. Aerzte* Vienna 1864; PIERRET, *Arch. de physiol.* IV (1871–72); FISCHER, *Arch. f. Psych.* V; HUPPERT, *ibid.* VII; KAHLER and PICK, *Prag. Zeitschr. f. Heilk.* II (1881), *Berl. klin. Woch.* 1879; JADERHOLM, *Nord. med. Arkiv* I; A. PICK, *Prag. med. Woch.* 1880; FLECHSIG, *Ueb. Systemerkrankungen* Leipzig 1878.

On heterotopia of grey matter, hypertrophy of the brain, and duplication of the cord:—VIRCHOW, *Krankh. Geschwulste* III, *Virch. Arch.* vol. 33; MESCHEDE, *Allg. Zeitschr. f. Psych.* XXI, *Virch. Arch.* vol. 56; E. WAGNER, *Arch. d. Heilk.* 1861; TUNGEL, *Virch. Arch.* vol. 16; PICK, *Prag. med. Woch.* 1881, *Arch. f. Psych.* VIII; MERKEL, *Virch. Arch.* vol. 38; SIMON, *ibid.* vol. 58; SCODA, *Allg. Wien. med. Zeitung* 1859; GELMO, *Jahrb. f. Kinderheilk.* IV (1860); STEINER and NEUREUTTER, *Prag. Vierteljahrsschr.* XX (1863); PFLEGER, *Cent. f. med. Wiss.* 1880; BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; LENHOSSECK, *Woch. d. Zeitschr. Wien. Aerzte* 1858; FURSTNER and ZACHER, *Arch. f. Psych.* XII; OSLER, *Journ. of Anat. and Physiol.* XV 1881 (so-called medullary neuroma).

VIRCHOW (*Gesamm. Abhandl.* 1856) found in a child 3 years old a brain weighing 1911 grammes, in another of 13 the brain weighed 1732. LANDOUZY (*Gaz. méd. de Paris* 1874) describes a brain of 1590 grammes in a boy of 10, and ZIEGLER has recorded one of 1857 grammes in a young woman of 20.

634. All the malformations of the brain above described, when they are not incompatible with life and growth, give rise to more or less grave disorder of its functions. Where the malformation is great mental development fails, and a condition of **idiocy** is the result. There is however no one variety of malformation which can be assigned as the anatomical basis of idiocy; there is in other words no special 'idiotic brain.' General arrest of development, dropsical dilatation of the ventricles, local defects or imperfections, all may result in idiocy. In other instances idiocy may accompany very slight and apparently unimportant abnormalities, such as heterotopia of grey matter, absence or smallness of the corpora albicantia, corpus callosum, fornix, thalamus, optic nerves, corpus striatum, pineal body, or olivary body, irregularity of the gyri, asymmetry of the hemispheres, etc.: or the brain may be so far as we can see perfectly normal, or hypertrophic through increase of the neuroglia. Lastly, ischaemic and inflammatory destructive processes affecting the cortex sometimes induce idiocy. On the other hand grave malformations such as we have just mentioned, and even others apparently more serious, have existed without giving during life any functional evidence of their presence.

In cretinism as in sporadic idiocy no special and characteristic defect of the brain can be demonstrated.

Cretinism is as we have seen (Art. 623 *a*) a disorder of development occasioned by some unknown miasmatic influence, and manifested in the imperfect growth of the skeleton and the disproportionate size of the soft parts. Idiocy more or less pronounced is a frequent though not invariable symptom, but malformation of the brain is not more general or constant than in idiocy without cretinism.

BENEDIKT some time ago asserted that in **criminals** certain peculiarities of the configuration of the cerebral surface were constantly met with, and inferred that criminals were practically to be regarded as an anthropological variety of the race. Their brains resembled in some points those of lower animals, and were characterised by a tendency of the sulci to run one into the other, so that they were continuous at points where in normal brains they would be bridged over or interrupted by convolutions. This hypothesis is however untenable. Apart from the difficulty of settling the definition of the term criminal, investigation has shown that BENEDIKT'S anomaly of the sulci occurs in persons who have never committed crime or come under the criminal law (BARDELEBEN).

The like holds for the anomalies and malformations of the brain found in certain **insane** and **epileptic patients**. They are none of them peculiar or pathognomonic of nervous or mental disease, inasmuch as they also occur in persons whose mental functions are perfectly normal. All we can say is—that anomalies

of brain-structure, both grave and trifling, are more frequent in persons who exhibit mental peculiarities or defects than in those whose minds are normal. Thus heterotopia of grey matter has been met with chiefly in lunatics, idiots, and epileptics; and in progressive paralysis (of the insane) various malformations of the brain are frequent in addition to the usual cortical changes characteristic of the disease (Art. 656).

Deficiency existing in places where according to our experience the centres governing certain specific functions are usually situate, or through which certain conducting paths usually pass, as a rule implies a like deficiency in the corresponding mental or other function, such as total or partial sensory or motor paralysis, and so on.

References :—VIRCHOW, *Gesamm. Abhandl.* 1856; KLEBS, *Stud. üb. d. Verbreit. d. Cretinismus in Oesterreich* Prague 1877; BENEDIKT, *Anat. Stud. an Verbrechergehirnen* Vienna 1879, *Cent f. med. Wiss* 1880; FLESCH, *Sitzungsber. d. phys.-med. Gesell. zu Wurzburg* 1881, *Unters. üb. Verbrechergehirne* Wurzburg 1882; BARDELEBEN, *Deut. med. Woch.* 1883; PETRINA, *Zeitschr. f. Heilk.* II; BINSWANGER, *Virch. Arch.* vol. 87; HARVOUET, *Arch. de physiol* IV 1884.

CHAPTER XCIII.

DISORDERS OF CIRCULATION.

635. The quantity of blood contained in the vessels of the cerebrospinal system is subject to very considerable physiological variations. It is greater when the system is functionally active than when it is at rest: the pulsations of the basilar arteries give rise to a pulsatile movement of the convexity of the brain, and its surface likewise rises during expiration and sinks during inspiration. Local hyperaemia of a particular region causes an efflux to other parts of the lymph from the circumvascular channels and of cerebrospinal liquid from the subarachnoid spaces and from the ventricles. When hyperaemia is general space is found for the excess of blood by the efflux of cerebrospinal liquid into the lymphatics of the head, neck, and trunk, and into the venous sinuses of the dura mater.

Morbid **congestion** or arterial hyperaemia of the brain and cord is occasioned when the activity of the heart is greatly and abnormally increased, or when the resistance to dilatation of the afferent arteries or of the arterioles of the meninges and nerve-substance is morbidly diminished. In the latter case the hyperaemia may remain local.

Passive hyperaemia or **engorgement** takes place when the return of venous blood from the cranial cavity and the spinal canal is checked, as it is for instance in certain diseases of the heart and lungs. Local engorgement may be due to intracranial thrombosis, or to tumours, exudations, etc. passing upon the veins.

Venous engorgement of the brain or cord is most apparent in the meninges, whose vessels are more or less distended with blood, and owing to the transparency of the membranes can be followed to their minutest ramifications. The meninges have but few capillaries, and hence the injection of the venules is most marked, though a few of the arterioles are also distended. It must however be kept in mind that the appearances after death are far from representing exactly the conditions that prevailed during life: as soon as death takes place the blood is in a measure free

to pass out of the cranium and the vertebral canal, while that which remains tends to sink to the parts that are most dependent.

Hyperaemia of the white matter is recognisable *post mortem* only by the distension of the small veins: on section they allow their contents to exude as variously-sized drops of blood. A general reddening of the tissue from dilatation of the capillaries is very uncommon, owing to the fact that the coagulation or post-mortem rigidity of the white matter squeezes most of their contents out of the capillaries, while the non-transparent nature of the coagulated white matter prevents the red tint from shining through.

In the grey matter the minuter venules and capillaries may remain filled with blood, the latter giving rise to a diffuse or mottled reddening of the tissue.

Anaemia of the central nervous system is manifested by the emptiness of the arterioles and venules of the pia mater, and the pallor of the grey matter. The white matter on section shows few or no drops of blood on its surface. This anaemia of brain and cord may be part of a general anaemia, or may be due to a morbid congestion of other organs or parts of the body (collateral anaemia). Or again it may result from spasmodic contraction, thickening, or other obstruction in the afferent arteries, or to changes within the cranium and vertebral canal which interfere with the entrance of blood, *e.g.* changes which diminish the space within these bony cavities, such as subarachnoid effusion, dropsy of the ventricles, tumours, haemorrhages beneath the dura mater, and so on.

Anaemia of the brain and cord is general or local according to the inducing condition. Local anaemia may for instance be caused by closure of a branch of the sylvian artery (middle cerebral), or by the pressure on the cord of a dislocated vertebra or a tumour of the dura mater.

References:—MARSHALL HALL, *The nervous system and its diseases* London 1836; MUNK, *Reichert's Arch.* 1853; REYNOLDS and BASTIAN, *Reynold's System of med.* II London 1868; LEYDEN, *Ueb. Hirndruck u. Hirnbewegungen*, *Virch. Arch.* vol. 37; F. JOLLY, *Untersuch. üb. d. Gehirndruck u. d. Blutbewegung im Schädel* Würzburg 1871; E. PAGENSTECHER, *Exp. Studien üb. Gehirndruck* Heidelberg 1871; ALTHANN, *Beitrage z. Physiol. u. Pathol. d. Circulation* Dorpat 1871; ACKERMANN, *Virch. Arch.* vol. 15; NOTHNAGEL, *Ziemssen's Cyclopaedia* XII; LANDOIS, *Cent. f. med. Wiss.* 1867; MOSSO, *Kreislauf d. Blutes im Gehirn* Leipzig 1881; MOXON, *Lancet* 1, 1881; ROSS, *Diseases of the nervous system* II London 1883; ADAMKIEWICZ, *Wiener Sitzungsber.* LXXXVIII 1883; OBERSTEINER, *Brain* VII 1884.

636. The brain and spinal cord are especially liable to **haemorrhage**, both by diapedesis and by rupture (Art. 27). In simple congestive hyperaemia some amount of capillary bleeding is not uncommon, and such bleeding is an almost invariable accompaniment of acute inflammatory disorder of the brain. In both cases the extravasations appear as round or oval specks of the size of a pea or smaller, often mottling the cut surface in a remarkable

way. The extravasated blood lies partly in the brain-tissue, partly in the sheaths of the vessels. In the latter position the small collections of blood are often described as miliary dissecting aneurysms.

In pyaemic encephalitis bacteria are sometimes to be seen in the vessels, and look as if they gave rise to capillary haemorrhage partly by obstructing and partly by destroying the walls of the vessels. In other cases the capillaries have undergone fatty degeneration.

When the arteries are obliterated by sclerotic thickening of the intima, by thrombosis, or by embolism, the haemorrhages are not usually very extensive; these changes more frequently give rise to a number of small isolated patches of extravasation.

Extreme venous engorgement, due for example to obstruction of the jugular veins or thrombosis of a sinus in the dura mater, frequently gives rise to capillary and venous haemorrhages situated chiefly in the pia mater and the ependyma of the ventricles. In the former situation they are sometimes so massive that the subarachnoid and subpial spaces are largely filled with blood. Engorgement within the brain, such as results from large tumours or old extravasations, usually leads to the formation of numerous small circumscribed patches, lying around the capillaries and small veins either in the sheaths of the vessels or in the nerve-substance itself.

Wounds, compressions, contusions, and concussions of the brain and cord due to traumatic violence give rise to bleeding whose extent is of course dependent on the number and magnitude of the ruptured vessels.

Extensive spontaneous haemorrhage (**apoplexy**) results from the rupture of an artery, and that only takes place when the arterial wall has from degenerative or inflammatory change lost its normal power of resistance (Arts. 297—300). Aneurysmal dilatation (Art. 303) usually though by no means always precedes rupture. Increased pressure within the arteries (so-called 'high tension'), such as generally accompanies the hypertrophied heart and contracted kidney of chronic nephritis or arteriosclerosis, is apt to lead to the rupture of diseased vessels, but not of healthy ones.

Spontaneous arterial haemorrhage takes place most frequently in and about the region of the basal ganglia and the internal capsule. It is less common about the pons, crura, cerebellum, and centrum ovale. It is least common on the convexity of the hemispheres.

This inequality of distribution depends on the fact that the arteries of the base are subject to a higher blood-pressure than the smaller vessels which pass from the arterial network of the pia mater into the grey matter of the cortex. This is especially true of the branches of the sylvian artery which supply the basal ganglia and the internal capsule.

Arterial haemorrhage results in disintegration of the nerve-tissue and ganglia over a more or less extensive area, and in compression of the parts surrounding the area. Only in the smallest capillary

haemorrhages can the nerve-tissue escape, and then it is simply compressed by accumulation of blood in the circumvascular sheaths. Rupture of the smallest arteries produces haemorrhagic foci varying from the size of a pea to that of a hazel-nut; in the case of the larger branches rupture may destroy entire segments of brain-tissue, such as the greater part of the basal ganglia of one side, together with part of the contiguous white substance, or the whole white centre of one occipital lobe.

A recent haemorrhagic patch forms a soft dark-red coagulated or pulpy mass, containing fragments of disintegrated nerve-tissue. When the haemorrhage is large the remainder of the brain is anaemic, the convolutions more or less flattened by pressure, and the furrows effaced. Round the chief focus lie a varying number of smaller foci mottling the cut surface, and due to the disturbance of the circulation set up by the primary haemorrhage. If the rupture takes place in the neighbourhood of a ventricle, blood may pass into its cavity and thence through the transverse fissures into the subarachnoid space.

Blood extravasated into the cortex is apt to collect beneath the pia mater and may also penetrate to the subarachnoid space. In haemorrhage from meningeal arteries these spaces are naturally the main seat of extravasation, the brain-substance being affected only in a secondary manner. When the arachnoid membrane is ruptured we have also subdural accumulations of blood.

As coagulation takes place, the haemorrhagic mass contracts and the watery portions of the blood are in part removed by means of the blood-vessels and lymphatics. The initial compression of surrounding parts is thus gradually diminished and at length ceases. At the same time the clot changes colour and becomes reddish-brown. Presently some of the colouring-matter (haemoglobin) is absorbed, tinging with yellow the parts around. At length the whole mass disintegrates (Art. 68), the detritus is in course of time absorbed (Arts. 638, 642), and the space so vacated is filled up either by exuded liquid or by the contraction and falling together of its walls. In the latter case a corresponding dilatation of the subarachnoid space or of the ventricles must take place. When the space is filled with liquid we have what is called an **apoplectic cyst**, when the space is effaced by contraction of its walls we have an **apoplectic cicatrix**. In either case there is usually some thickening and induration of the walls (Art. 639), which are stained of a yellow, brownish-red, or brown colour, while some of the pigment derived from the extravasated blood remains unabsorbed as brown flakes and granules of ferric hydrate, with perhaps a few particles or crystals of haematoidin. The induration is due partly to fibrous hyperplasia of the sheaths of the blood-vessels, partly to proliferation of the neuroglia.

When the haemorrhage is small and confined to the sheaths of the vessels, and so does not involve any destruction of nerve-tissue,

the products of disintegration of the extravasated blood are for the most part carried off by the circumvascular lymphatics, though granules of pigment frequently lie for a long time embedded in the adventitial sheaths.

Our knowledge of the genesis and history of spontaneous haemorrhage in the brain is largely due to CHARCOT (*Les maladies des vieillards* Paris 1867, *Diseases of old age* (New Syd. Soc.) London 1881). He affirms that small or **miliary aneurysms** (described by VIRCHOW in *Virch. Arch.* vol. 3; see also BOUCHARD, *Pathology of cerebral haemorrhage* London 1872) are always present, and sometimes in great numbers, in cases of arterial haemorrhage. They are due he thinks to periarteritis, which leads to infiltration and thickening of the adventitial and pial sheaths, and to atrophy of the muscular coat. The author finds that CHARCOT'S statement applies only to a certain number of cerebral and spinal haemorrhages. The aneurysmal dilatation does not always precede rupture: and as to the cause of the dilatation he agrees with ZENKER (*Naturforscherversammlung in Leipzig* 1872), EICHLER (*D. Arch. f. klin. Med.* XXII), COATS (*Trans. internat. med. congress* I London 1881), LÖWENFELD (*Arbeiten aus dem pathologischen Institut zu München* 1886), and others, that it may be due to atheromatous degeneration, or even to primary degeneration of the muscularis alone. This last is not always of an amyloid nature, as ROTH maintained (*Corresp. f. Schweizer Aerzte* 1874); at least cases occur in which the muscular fibres are either simply absent or exhibit a fatty or hyaline change which gives no iodine-reaction (PAGET, *Surg. Path.* London 1863). The accumulation of cells and the fibrous thickenings in the sheaths of the vessels described by CHARCOT are doubtless in some instances of a secondary nature. See CHARLEWOOD TURNER, *Trans. Path. Soc.* XXXV 1884.

The '**miliary dissecting aneurysms**' (first described by KÖLLIKER in 1849) are most frequently met with in cases of acute inflammatory congestion. The term is strictly-speaking incorrect, inasmuch as the blood does not collect between the media and the adventitia (Art. 309), but between the vessel-wall and the pial sheath.

Both ruptured and unruptured aneurysms of the cerebral vessels may be filled up with white or laminated clot and so become obliterated.

637. **Oedema** of the brain and cord is characterised chiefly by abnormal moistness of the grey and white matter, so that it has a glistening appearance on section. Owing to the peculiar structure of the central nervous system the dropsical liquid accumulates not so much in the parenchyma of the nerve-tissue itself as in the wide lymph-spaces which it contains. These are chiefly the pial sheaths of the vessels, the ventricles, the central canal of the cord, and the subarachnoid and pial spaces. We thus distinguish oedema of the nerve-tissue from oedema of the pial sheaths of the vessels, of the membranes (*hydrops meningeus*), of the ventricles (*hydrops ventriculorum* or *hydrocephalus internus*), and of the central canal (*hydromyelia*). In dropsy of the sheaths of the vessels the circumvascular lymph-spaces are distended with liquid, so that the vessels appear insulated as they run through the tissue. Sometimes small cysts are thus formed (SCHLESINGER) with a vessel running axially through them.

In oedema of the membranes there is always an increase of the subarachnoid liquid, more rarely of that in the subdural space (*hydrocephalus externus*). Over the surface of the brain the sulci

appear somewhat widened out. This change sometimes extends over the whole brain and cord, sometimes is limited to a particular region: in the latter case the boundary of the dropsical part is indefinite or it is so sharply defined that the distended subarachnoid and pial spaces resemble cysts (cystic or vesicular oedema). These dilatations are met with both on the surface and in connexion with the processes of the pia mater which lie inside the ventricles, namely the telae choroideae and their plexuses. The latter especially sometimes carry cysts of the size of a bean or larger and filled with clear liquid. The cyst-walls consist of vascular connective tissue covered externally with flat polygonal epithelium and internally with endothelium. The cavity of the cyst is often traversed by vessels and delicate fibrous bands. Small cysts of this kind are of no great importance, but the larger ones may cause serious compression of the brain and lead to disturbance of its functions.

Ventricular dropsy implies the distension and dilatation of one or all the ventricular cavities: hydromyelia leads to cylindrical, fusiform, globular, or more rarely saccular dilatations of the central canal.

The causation of accumulations of liquid within the central nervous structures is not entirely the same as that of dropsy in other organs: to a certain extent they are of a peculiar nature, and to understand them we must somewhat widen our notion of what dropsy implies.

An **oedema of engorgement** may take place over say the whole of the brain whenever the outflow of venous blood from the cranial cavity is impeded. This occurs suddenly when the heart is paralysed, as in some cases of typhoid (BUHL, KRAPELIN), when the veins of the dura mater are occluded by thrombosis, etc. Chronic disease of the heart or lungs impeding the circulation will in like manner give rise to chronic oedema. Acute engorgement usually leads to accumulation of liquid in the parenchyma of the brain as well as in the subarachnoid tissue, chronic engorgement usually in the latter only or chiefly.

Local oedema of engorgement is very common round about haemorrhagic foci, tumours, localised venous thromboses, etc. When by reason of a tumour or of inflammatory change the outflow of blood from the choroid plexuses is impeded, and the outflow of cerebrospinal liquid from the ventricles and central canal is at the same time checked, liquid will accumulate to a greater or less extent in these cavities and distend them. According to LANGHANS fusiform and even saccular dilatations of the central canal are sometimes produced by this cause; they project into the posterior longitudinal fissure of the cord and usually take a downward direction. He also states that clefts or spaces containing effused liquid occasionally appear in the grey matter of the posterior commissure and of the anterior and posterior horns; these may fitly be described as **dropsical lacunae**.

The so-called **hydraemic dropsy** occurs chiefly in connexion with nephritis, and affects the brain-substance as well as the membranes.

Inflammatory oedema is set up within the substance of the brain and cord in the neighbourhood of foci of inflammation, sometimes also around tumours and patches of softening. In the membranes it may be the chief symptom of a slight meningitis, though it accompanies almost every form of localised disease of the superficial parts of the central nervous system. In the ventricles and central canal it results from inflammatory changes in the vessels of the plexuses and the ependyma, and is sometimes very extensive. It is acute or chronic according to the affection which induces it. When the inflammatory effusion in the ventricles is abundant the convolutions are compressed against the skull and flattened, while the blood and lymph are gradually squeezed out of the enveloping membranes.

Acute general **congestive oedema** of the brain is said to be commonest in children and as a result of acute congestive hyperaemia. The sudden congestion increases the intra-cranial pressure, and so compresses the capillaries and veins that the outflow of blood from the meninges is hindered: in this way secondary engorgement and oedema are produced (HUGUENIN).

It is not possible to distinguish sharply between congestive and inflammatory oedema: on the contrary it is highly probable (JÜRGENSEN) that so-called congestive oedema often represents merely an early stage of a rapidly fatal inflammation (Arts. 652, 653).

When the brain and cord diminish in size, the space they leave unoccupied is usually filled up by the collection of liquid in the subarachnoid space: this is described as **meningeal dropsy** *ex vacuo*. Sometimes the ventricles are at the same time dilated. The volume of the brain may diminish rapidly as in extreme anaemia, profuse diarrhoea, infantile marasmus, etc. or slowly and gradually as in senile atrophy. The like happens to a limited extent when parts of the brain or cord lying just beneath the ependyma or pia mater are lost in consequence of some destructive process. When the nerve-substance in the interior of the central organs undergoes atrophy the space vacated is sometimes filled by liquid gathering in the circumvascular channels of the affected region itself. This is especially apt to occur when the atrophy has been preceded by abnormal dilatation of the vessels or distension of the lymphatics within the brain, so that the circumvascular lymph-spaces are already abnormally capacious. If the condition is widespread, affecting a considerable number of vessels, the brain on section appears riddled with perforations and the condition is referred to as *état criblé* (Art. 643).

Extensive loss of substance in the interior of the brain or cord, whether due to haemorrhage, softening, or inflammation, leads (after absorption of the detritus) to the formation of cavities which

are generally filled up in part by clear or turbid liquid: these are described as **cysts**. If they are small and numerous the apparent perforation of the tissue is also described as *état criblé* ('Gruyère cheese condition': see SAVAGE and WHITE, *Trans. Path. Soc.* XXXIV 1883).

Vesicular oedema or cysts of the pia mater would appear to depend on the presence of closed lymph-spaces, congenital or acquired, in the pia mater and subarachnoid tissue.

An interesting affection of the cord called **syringomyelia** should be mentioned in this connexion. The term is applied to a condition in which fissures and cavities occur, chiefly in the posterior grey commissure and about the median plane, and often extending longitudinally over a considerable distance. Not infrequently the excavation extends into the posterior horns, traversing them sometimes transversely sometimes obliquely, or into the posterior columns; very rarely extending as far as the anterior horns, the anterior commissure, or the lateral columns.

These fissures and cavities may occur in any part of the cord, they have even been observed in the medulla oblongata (SCHULTZE). They are always enclosed by a delicate more or less cellular neuroglial tissue, and are in part due to the breaking down of some gliomatous proliferation of this tissue. Their contents are either clear liquid or a kind of hyaline jelly. The proliferation which precedes their excavation starts as a rule in the neuroglia about the central canal, though it may also originate in remoter portions of either grey or white matter. From the facts at present before us it seems likely that the starting-point in most cases is some congenital histological anomaly in the posterior commissure, which interferes with the closure of the central canal and so with the development of the posterior columns. In many cases syringomyelia is thus a consequence of congenital hydromyelia (LEYDEN), and that either because some abstricted remnants of the medullary tube persist behind the central canal, or because malformation of the central canal is associated with histological changes in the parts about it which predispose to abnormal proliferation and subsequent disintegration of tissue (Art. 650). With reference to the supposed abstriction and persistence of parts of the medullary tube it should be mentioned that several observers (SCHUPPEL, PICK) have recorded instances of duplication and even triplication of the central canal for some part of its length, each tube being lined with cylindrical epithelium.

Various explanations of syringomyelia have been given. SIMON and F. SCHULTZE refer it to the disintegration of proliferous neuroglia. LANGHANS maintains that obstructions to the flow of blood or lymph, such as are caused for example by the growth of tumours, give rise to dilatations and even sacculations of the central canal. Such saccular diverticula extend through the posterior columns and adjacent parts usually in a downward direction, and so form as it were a segment of a second canal behind the central canal. Dropsical lacunae may also be formed by the collection of gelatinous liquid

in the grey commissure and the posterior horns. The appearances would thus be accounted for. LEYDEN regards syringomyelia as resulting from congenital hydromyelia in the manner described in the text. WESTPHAL takes a like view, which is rendered at least possible by the fact that the central canal even in a foetus of the fifth month still extends to the posterior margin of the cord.

ZIEGLER agrees with those who think the affection is essentially due to an excavation of proliferous neuroglia. LANGHANS is no doubt right in stating that tumours of the cord and medulla give rise to very remarkable dilatations of the central canal, and it is not hard to believe that actual diverticula are occasionally produced. But these should properly be considered as cases of hydromyelia, and they do not exclude the possibility of an excavation of proliferous tissue; to this latter it would perhaps be well to limit the term syringomyelia. Probably too we shall be right in referring the whole process to a congenital anomaly of development, the proliferation depending on some morbid structure of the neuroglia, accompanying or following upon defective closure of the canal or defective elaboration of the grey or white matter in its neighbourhood.

References on syringomyelia and duplication of the central canal:—NONAT, *Archives générales* 1838; GULL, *Guy's Hosp. Reports* VIII (1862); HALLOPEAU, *Archives générales* 1871–72; VIRCHOW, *Virch. Arch.* vol. 27; KESTEVEN, *St Barth. Hosp. Reports* VIII (1872); WESTPHAL, *Arch. f. Psychiatrie* V (1874), *Brain* VI (1883); SIMON, *ibid.*; LEYDEN, *Klinik d. Rückenmarkskr.* II 1877, *Virch Arch.* vol. 68; STRÜMPELL, *Arch. f. Psych.* X; FRIEDREICH, *Virch. Arch.* vols. 26, 27; GRIMM, *ibid.* vol. 48; LANGHANS, *ibid.* vol. 85; REISINGER, *ibid.* vol. 98; F. SCHULTZE, *ibid.* vol. 87; SCHUPPEL, *Arch. d. Heilk.* VI (1864); PICK, *Arch. f. Psych.* VIII.; WITKOWSKI, *Arch. f. Psych.* XIV (1883); FURSTNER and ZACHER, *ibid.* XIV; TAYLOR, *Trans. Path. Soc.* XXIX (1878), XXXV (1884); WHIPHAM, *ibid.* XXXII (1881); KRAUSS, *Virch. Arch.* vol. 101; HARRIS, *Brain* VIII (1886).

On cysts of the meninges, choroid plexus, etc.:—ZENKER, *Virch. Arch.* vol. 12; HAECKEL, *ibid.* vol. 16; LUSCHKA, *Die Adergeflechte d. mensch. Gehirnes* Berlin 1855; ROKITANSKY, *Path. Anat.* III London 1850; RIPPING, *Cystoide Degen. d. Hirnrinde, Allg. Zeitschr. f. Psych.* vols. 30, 32 (1874–65); SCHOPFHAGEN, *Wiener Sitzungsber.* LXXIV (1876); SCHLESINGER, *Arch. f. Psych.* X; ARNDT, *Virch. Arch.* vols. 63, 72.

According to BUHL (*Henle u. Pfeuffer's Zeitschr. f. rat. Med.* IV (1858)) the amount of water in the brain in typhoid fever increases up to the beginning of the third week, the increase amounting to 9 or 10 per cent. above the normal.

CHAPTER XCIV.

SIMPLE AND DEGENERATIVE ATROPHY.

638. In all **degenerative processes** affecting the central nervous system the nerve-elements are the first to disintegrate and disappear, while the neuroglia frequently persists unchanged or actually increases.

Ganglion-cells atrophy by simple shrinking of their protoplasm without visible change of structure; when they lose their processes they appear as little shrunken specks (Figs. 257, 258, Art. 640) and at length disappear altogether: this is **simple atrophy**.

Pigmented ganglion-cells as they shrink appear to be still more deeply tinted; indeed it sometimes looks as if the actual amount of pigment were increased during the atrophic process. This form has been called **pigmentary atrophy**.



FIG. 250. DEGENERATION OF CELLS AND FIBRES FROM THE CEREBRAL CORTEX.

(*From the border of an encephalitic patch eight days old: the preparation macerated in Müller's fluid and then teased out:* × 300)

- *a* swollen and hyaline ganglion-cells, with processes already splitting up
- a_1 pale denucleated cell beginning to split into fragments
- a_2 cell resolved into oil-globules
- *b* axis-cylinder swollen up and splitting
- *c* normal ganglion-cell

In acute destruction of the ganglion-cells, such as occurs in the neighbourhood of inflamed areas, after sudden compression, anaemic and haemorrhagic softening, and so on, the cells and their processes frequently swell up (Fig. 250) and become pale and hyaline (a). Sometimes vacuoles appear, and the nuclei partake in the general swelling. After a time the cells split up and dissolve away (a_1), the nuclei at the same time disappearing. **Fatty degeneration** of the cells may also occur (a_2) under the same conditions, but it is more common in cases where chronic or recurrent disorder of the circulation leads to defective nutrition of the cells. In such cases it may be the only change that is perceptible: it may occur in patches or extend over the cortex. Fatty change of this kind is met with in many forms of mental disease.

When the ganglion-cells have once perished, whether from inflammation, anaemia, sudden compression, or other cause, and do not at once dissolve, they sometimes undergo **calcification** (Fig. 251), becoming as it were tightly crammed with particles and spherules of calcareous matter. FRIEDLANDER found a calcified ganglion-cell thirteen days after a wound of the part. In chronic diseases the cells sometimes take on a glistening wax-like appearance, a change which has been described as sclerosis of the ganglion-cells.



FIG. 251. CALCIFIED GANGLION-CELLS AND FIBRES.

(*From the brain of a hemiplegic idiot with unilateral hydrocephalus:* × 300)

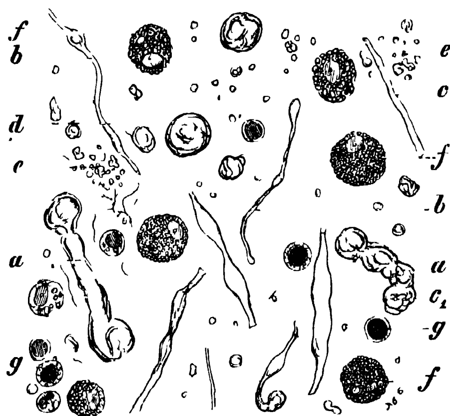


FIG. 252. DEGENERATION OF THE CORD FROM PRESSURE.

(*White matter teased out:* × 300)

- a nerve-fibre with coagulated myeline
- b axis-cylinder with myeline attached
- c naked axis-cylinder, c_1 another much swollen
- d free globules of myeline
- e free detritus
- f granule-spheres (cells crammed with detritus)
- g small round-cells (leucocytes)

In the **degeneration of nerve fibres** (at least of the medullated kind) the medullary sheath is the first part to disintegrate. When

for example a portion of the brain or cord is destroyed by traumatic violence or by anaemic or inflammatory softening, the disintegrated tissue contains nerve-fibres whose sheath consists of myeline in a peculiar state of coagulation (Fig. 252 *a*), together with naked or sheathless axis-cylinders (cc_1), free drops or globules of myeline (*d*), and small spheres (*e*) of fatty detritus derived from the disintegration of myeline. The axis-cylinders are sometimes unaltered, som•etimes greatly swollen (c_1), with such irregular and wavy outlines that they have been described as varicose. Soon they become fragmented and are absorbed; sometimes however globular masses of altered myeline accumulate at certain points of their length and thus give them a varicose appearance (*b*) from another cause.

The process of degeneration is similar in cases that are chronic or less acute, as in the peripheral parts of nerves that are severed from their centres (Art. 646).

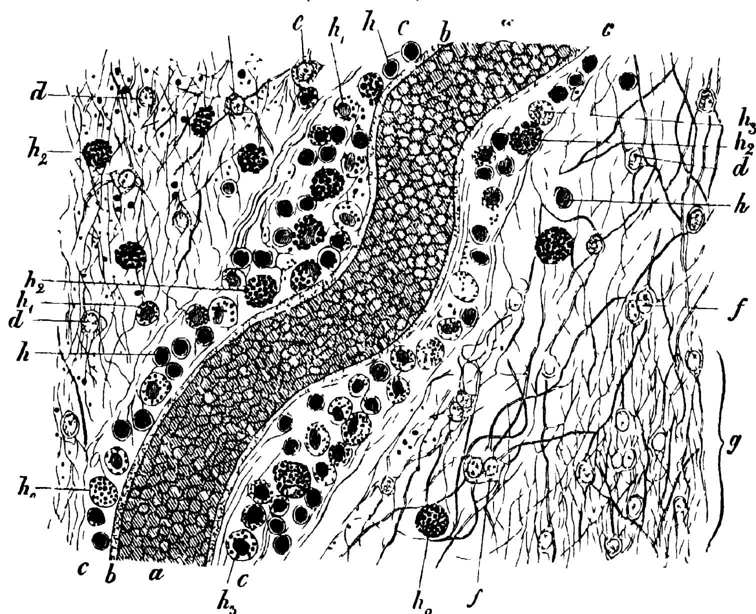


FIG. 253. DEGENERATING PATCH FROM A CASE OF MULTIPLE SCLEROSIS OF THE BRAIN.

(*Prepared by treating with perosmic acid and teasing:* × 200)

blood-vessel filled with blood
tunica media
adventitial lymph-sheath
unaltered meuroglia-cells
fatty neuroglia-cells
binuclear neuroglia-cells

g sclerotic tissue
h lymphoid cells and leucocytes
h_1 cells containing a few oil-globules
h_2 fat-granule cells
h_3 pigment-granule cells

Wherever nerve-fibres thus undergo degeneration it is sooner or later accompanied by extravasation of liquid and of white blood-cells from the neighbouring vessels. Part of the detritus dissolves

in the exudation and is thus absorbed. The undissolved remainder is taken up chiefly by the white blood-cells which thus become myeline-carriers and fat-granule cells (Fig. 252 *f*, Fig. 253 h_2). The latter are always present when disintegrative processes are going on. If blood should have escaped from the vessels during the process, pigment-granule cells (Fig. 253 h_3) will also be found.

The free detritus and the carrier-cells are in the course of time conveyed into the circumvascular lymph-channels (Fig. 253 *c*) of the affected region and by them removed.

When the degeneration is extensive not only the neighbouring lymphatics but also those more remote are crammed with granules and granule-carrying cells. If these reach the meshes of the pia mater or the subarachnoid space they give the tissue a milky and turbid appearance.

Corpora amylacea (Art. 61), which are normally met with in the brain-tissue, are found in increased numbers where degeneration has taken place.

Regeneration of the nerve elements of the brain and cord appears never to occur, at least in man. When ganglion-cells and the nerve-tracts corresponding to them are once destroyed, the functions they performed can only be restored by the substitution of equivalent centres and tracts capable of functionally replacing them.

The above-mentioned form of disintegration of the myeline of nerve-fibres is usually described as fatty degeneration, inasmuch as the myeline-detritus after a time gives the microchemical reactions of fat.

When the tissues of the brain and cord, with their membranes and lymphatics, are found to contain granule-carrying cells, it may in general be regarded as evidence that disintegration of nerve-substance has taken place at some point or other. According to JASTROWITZ (*Arch. f. Psych.* II) this applies only to persons more than seven months old. From the fifth month of gestation to the seventh month after birth such granule-cells occur normally in various parts of the central nervous system, depending on the stage of growth: they appear to be connected with the development of the medullary nerve-sheaths. According to BOLL the material for the formation of these sheaths is brought to the fibres by migratory cells. Formerly their presence was supposed to indicate a morbid change described as **congenital encephalitis**. VIRCHOW has however re-asserted (*Berl. klin. Woch.* 46, 1883) the pathological nature of the granule-cells found in the brain of new-born infants, arguing that the granules give the microchemical reactions of fat but not those of myeline, that they are not constantly found, and that they are accompanied by swelling of the neuroglia-cells and multiplication of nuclei, and that occasionally some degeneration of nerve-tissue is present. The granule-cells are either scattered diffusely or grouped in clusters which form opaque white patches on the greyish-red surface of the foetal brain, and are quite visible by the unaided eye.

Not infrequently the pia mater about the base of the brain exhibits a deep-brown **staining**. It is usually due to an exceptional development of the stellate pigment-cells normally found in the pia mater, and is therefore not pathological. Morbid pigmentation of the membrane is as we have seen sometimes caused by haemorrhagic effusions.

The mode in which the **amyloid concretions** are produced is not certainly

known. CECI has recently (*Transunti d. real. accad. dei Lincei* v) called attention to the fact that they do not always give the iodine-reaction, while they are stained brown or black by perosmic acid, differing in this from ordinary amyloid substance. In their double-refracting power and in their reactions they resemble myeline, and CECI suggests that they may consist of or be derived from that substance.

The question of the regeneration of the tissues of the central nervous system and especially of the cord has frequently been the subject of experimental enquiry. H. MÜLLER experimented on lizards and fishes (*Ueb. Regeneration d. Wirbelsäule u. d. Rückenmarkes* Frankfort 1864), MASIUS and VANLAIR (*Mém. de l'acad. de Belgique* XXI (1870)) on frogs, while BROWN-SÉQUARD (*Gaz. méd.* 1849, '50, '51), EICHHORST and NAUNYN (*Arch. f. exp. Path.* II), DENTAN (*Rech. sur la régénération de la moelle épinière* In. Diss. Berne 1875), and SCHIEFFERDECKER (*Virch. Arch.* vol. 67) used dogs. Some of the results were negative, others pointed to functional and histological regeneration of the severed cord. Nevertheless it cannot be considered as proved that this regeneration takes place in mammals.

References on the behaviour of ganglion-cells and nerve-fibres in degeneration:—VIRCHOW, *Virch. Arch.* vols. 10, 44, 50; LEYDEN, *Klinik d. Ruckenmarkskr.* 1874—76, *Zeitschr. f. klin. Med.* I (1879); OBERSTEINER, *Wiener med. Jahrb.* III, IV (1879); JAHN, *Arch. f. Pysch.* VIII; ZENKER, *Arch. f. Ophthalm.* II; MULLER, *Beitr. z. path. Anat. d. Ruckenmarkes* Leipzig 1871; CHARCOT, *Maladies du syst. nerv.* Paris 1877—80, *Diseases of the nervous system* (New Syd. Soc.) London 1876—80; MESCHEDE, *Virch. Arch.* vol. 34; MOBIUS, *Schmidt's Jahrb.* 190, 193 (a summary of recent memoirs on nervous diseases); WIEGER, *Virch. Arch.* vol. 78 (references on hyaline degeneration of cerebral vessels); HADLICH, *ibid.* vol 46; SALVIOLI, *Rivista clin. di Bologna* 10, 1878; ROTH, *Virch. Arch.* vol. 53; FRIEDLANDER, *ibid.* vol. 88. The last three authors refer specially to calcification of ganglion-cells either as an accompaniment of degeneration or as an independent affection. VIRCHOW met with it chiefly as a consequence of concussion of the brain. On senile degenerative changes in the cells of the cortex see KOSTJURIN and HESS, *Wiener med. Jahrb.* 1886.

639. When a large area of nerve-tissue is destroyed the **neuroglia** is apt at the same time to undergo partial necrosis, or at least to show evidence of fatty degeneration in its tissue-cells (Fig. 253 *e*). In like manner the endothelium of the pia mater and of the blood-vessels may become fatty. When the destruction of tissue is less extensive the nerve-elements alone persist, while the neuroglia with its vessels and their supporting fibrous structures remain intact.

After absorption of the products of disintegration of the nerve-elements the neuroglia of the white matter of the brain has the appearance of a network of anastomosing stellate cells (Fig. 254 bb_1). The fibrils of these cells are very fine, and in hardened sections at least have a granular appearance, which is most marked in recent preparations where the degeneration is not advanced. When the absorption of the nerve-tissue is incomplete, the meshes of the connective tissue contain particles of detritus and granule-carrying cells (Fig. 254 *e*).

The white matter of the cord in degeneration resembles that of the brain (Fig. 255 *B*), but the network (*c*) of connective tissue which originally surrounded the parallel nerve-fibres appears much more regular and at the same time stouter. The meshes contain

either liquid or the detritus of the nerve-fibres together with granule-cells (*d*) and a few leucocytes.

The neuroglia of the grey matter, like that of the white, may persist after the nerve-elements have disappeared The tissue in hardened sections appears granular (Fig. 258) and beset with the



FIG. 254. SECTION THROUGH THE MARGIN OF A PATCH OF SOFTENING IN THE BRAIN.
(*Hardened in Muller's fluid, stained with haematoxylin and carmine, and mounted in Canada balsam* × 250)

A normal tissue
a nerve-fibres cut across at various
b normal neuroglia-cells
b_1 persisting neuroglia-cells
c blood vessel
c_1 blood-vessel with thickened sheath

B degenerate tissue
d extravasated but unaltered white blood-cells
e fat-granule cells which have lost their fat during the treatment of the section with alcohol and clove-oil

nuclei of neuroglia-cells. In the cortex of the brain fibrils make their appearance which at their intersections exhibit small masses of protoplasm with or without nuclei. Here and there cells can be seen giving off processes resembling the fibrils. As degeneration proceeds a delicate granular meshwork (Fig. 260 *a* Art. 642, Fig. 271 Art. 650), with cells placed at some of the intersections, is all that remains. Ultimately this too disappears, so that nothing persists but the blood-vessels (Fig. 260 *b*, Fig. 254 cc_1).

In many cases the persisting neuroglia itself ultimately perishes. In others it remains quiescent or undergoes hyperplasia. So far as can be made out the process begins by subdivision and multiplication of the persisting nuclei of the tissue-cells (Fig. 253 *f*, Fig. 254 *B*). This is followed by cell-multiplication and fibrillation, and the resulting new tissue appears like a felted mass of delicate

translucent fibrils and nucleated cells, enclosing particles of detritus and liquid (Fig. 253 *g*, Fig. 256 *b*). Some of the fibrils are connected with the neuroglia-cells, forming processes as it were; others seem to have no such connexion (Fig. 253).

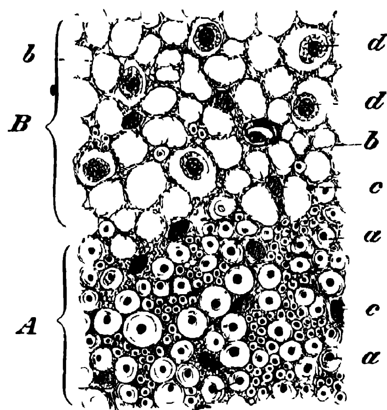


FIG. 255. ASCENDING DEGENERATION OF THE CORD (RECENT).

(*Section taken from a cord which had been severely compressed ten weeks before: hardened in Müller's fluid, stained with haematoxylin and carmine, and mounted in Canada balsam:* × 250)

A normal white matter
B degenerate white matter

a normal nerve-fibres
b neuroglia
c neuroglia-cells
d fat-granule cells (fat dissolved out)

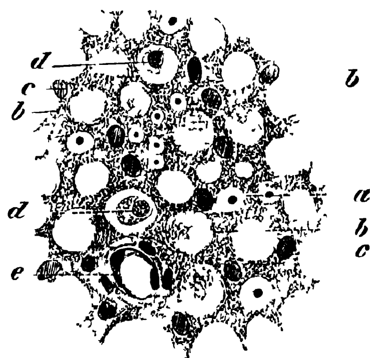


FIG. 256. ASCENDING DEGENERATION OF THE CORD (ADVANCED).

(*Section taken from a cord severely compressed eighteen months before: prepared as in Fig.* 252. × 250)

a section across nerve-fibres
b hyperplastic neuroglia
c nuclei of neuroglia-cells
d fat-granule cells (fat dissolved out)

Frequently the walls of the blood-vessels, and especially the adventitial tissue, take part in the hyperplastic process. The vessels then look as if beset and studded with proliferous cells, and the adventitia is thicker and more densely fibrous than usual (Fig. 254 c_1).

So long as a degenerating patch contains detritus of nerve-tissue it appears white and opaque and is of soft consistence. If the disintegration is extreme it may be almost diffluent on section. After absorption of the products of disintegration the tissue becomes grey and translucent. When hyperplasia of the neuroglia ensues a grey gelatinous patch is formed; such patches are occasionally described as instances of **grey degeneration.**

When the new-formed fibrils are scanty and their meshes wide and filled with liquid, the patch is soft; on section it allows the liquid to escape and retracts below the general surface. If the fibrils are abundant and the resulting felted mass close-meshed, the patch is firm and dense. These two varieties correspond to soft or

gelatinous degeneration and firm grey degeneration or **sclerosis.** The sclerotic tissue by contraction may become tough and cicatricial, but this requires months and probably years.

The behaviour of the blood-vessels varies according to the form of the degenerative process As a rule however in the later stages hyperplasia of the adventitia and thickening of the vessel-walls take place.

The more intimate **structure of the neuroglia** or supporting framework of the nervous system, and the significance of its several elements, are matters which are still under discussion

SCHWALBE distinguishes three constituents, namely (1) the epithelium of the ventricles and central canal, (2) the neuroglia, which in life forms a homogeneous cementing substance between the nerve elements but after death is resolved by coagulation into delicate reticular fibrils, (3) a 'granular substance' which forms a very close meshed network and is composed of neuro-keratin (EWALD and KUHNE) All of these, he says, are derived from epithelial structures The neuroglia it is true contains flattened (endotheloid) cells, but they are to be regarded as migratory cells which have become modified

KOLLIKER, DEITERS, JASTROWITZ, BOLL, LOWE, GOLGI, FRIEDMANN, and others assign the neuroglia to the connective tissues, and give as its constituents a fibrillar network, a granular matrix or ground-substance, and cells both stellate and simple

SCHWALBE'S account of the neuroglia does not agree with the experience of pathologists It is a tissue which to some extent is *sui generis*, some of its properties resembling those of no other structure, but it must nevertheless be classed with the connective tissues

Both grey and white matter contain besides nerve-cells round or oval cells with scanty protoplasm and numerous fine processes either radiating in all directions (stellate cells) or running more or less parallel (Fig 253 *ef*, Fig 254 c_1, Fig 268) These were first described by DEITERS and are called **Deiters' cells.** The number of the processes and the form of the cells vary much in different parts

There are also certain rounded or polygonal cells without processes, which are either undeveloped Deiters' cells or migratory cells

The ground-substance surrounding the cells consists of a finely-granular reticulate structure through which the processes of the cells ramify It is not yet certain whether all the fibrils that are seen communicate with cells. In the white matter the granular structure is scanty or absent, in the grey matter it is abundant, and the nerve-fibres and ganglion-cells seem as if embedded in it It is questionable however whether the ground-substance is granular during life According to GIERKE (*Neurol Centralb* 1883, *Arch. f mikrosk Anat* XXVI 1885) it is homogeneous and transparent

SCHULTZE and RUMPF (*Cent f med Wiss* 1878) have found that in hyperplasia of the neuroglia, where a dense felted mass of fibrils is produced, the so-called neuro-keratin of KUHNE does not increase in quantity, and the new fibrils react to digestive agents just like fibrous tissue

The terms grey degeneration and sclerosis have been used as if they were equivalent terms Strictly speaking σκληρος means hard and dry, and the term **sclerosis** should be limited to hardening accompanied by loss of moisture (Art 650)

References on the histology of the central nervous system —HENLE and MERKEL, *Zeitschr. f. rat Med.* (3rd series) vol 34, LOCKHART CLARKE, *Phil Trans* 1851, '58, '59, '62; DEITERS, *Unters ub Gehirn u. Ruckenmark* Brunswick 1865; MEYNERT, *Bau d. Grosshirnrinde* Neuwied 1869; GERLACH, *Stricker's Man. of Histology* II (New Syd Soc) London 1872; JASTROWITZ, *Arch. f. Psych.* II, III; BOLL, *ibid.* IV (1873); LOWE, *ibid.* VII (1877); STIEDA,

Zeitschr. f. wiss. Zool. XVIII, XIX, XX, XXIII, XXV; RANVIER, *Comptes rendus* LXXVII (1873), *Histologie du syst. nerv.* Paris 1878, *Arch. de physiol.* XV 1883 (structure of neuroglia); GOLGI, *Rivista clinica* Nov. 1871, *Arch. ital. de biologie* III, IV; SCHWALBE, *Handb. d. Augenheilk.* (*Grafe and Samisch*) I, *Lehrb. d. Neurol.* Erlangen 1881; FRIEDMANN, *Jahrbücher f. Psych.* 1883; EWALD and KUHNE, *Verh. d. nat. med. Vereines zu Heidelberg* I; Duke KARL THEODOR of Bavaria, *Virch. Arch.* vol. 69; J. WEISS, *Med. Jahrbücher* 1878; TURNER, *Journ. of Anat. and Physiol.* XIII 1879 (descriptive summary of recent memoirs); SCHOPFHAGEN, *Jahrbuch f. Psych.* III (1881); KLEIN and NOBLE SMITH, *Atlas of Histology* London 1880; *Quain's Anatomy* II London 1882; HOLLIS, *Journ. of Anat. and Physiol.* XVII, XVIII, XIX.

640. **Simple atrophy.** This term is applied to those changes in the brain and cord which are characterised by dwindling and partial disappearance of the nerve-elements without any marked textural alteration either preceding or following. The atrophy is either general or at least extensive, or it is confined to particular parts of the brain and cord.

Atrophy of the **cerebrum** is the commonest example of the extensive form; the whole or the greater part of the hemispheres diminishing more or less in volume, the gyri becoming narrower, and the sulci with the subarachnoid spaces wider and filled with liquid. Not infrequently the ventricles also are dilated.

Atrophy of the **cerebellum** or of the **medulla** and **cord** is much less common: cases are however recorded in which the cerebellum was so shrunken that its volume was less than half the normal and its gyri were almost filiform. In most instances the atrophy is not uniformly diffused, but is most evident in one or two of the lobes or in particular convolutions. The atrophied parts are usually firmer and denser than the healthy parts.

Atrophy of the pons, of the medulla, and of the cord, is sometimes symmetrical, sometimes unsymmetrical, and may affect the nerve-tracts as well as the ganglion-cells.

The forms of local atrophy most amenable to microscopical investigation are those which are met with in the anterior horns of the cord and in the motor nuclei of the medulla (bulbar nuclei), and which form the anatomical basis of certain nervous diseases variously named by clinical observers.

The anterior horns (Fig. 257) of the cord consist of a tissue whose characteristic elements are large multipolar ganglion-cells (*a*) and numerous tracts of medullated nerve-fibres (*b*), whence the anterior roots (b_1) of the spinal nerves take their origin. Between these elements is a complex texture of stout and slender nerve-fibres (*d*), the whole being embedded in a delicate nucleated neuroglia (*e*).

In simple **atrophy of the anterior horns** (Fig. 258) the ganglion-cells and then the nerve-fibres are lost; so far as can be made out they simply dwindle and disappear. The ganglion-cells (*a*) lose their processes and shrink up into small pigmented lumps: when these perish nothing remains but a few grains of pigment,

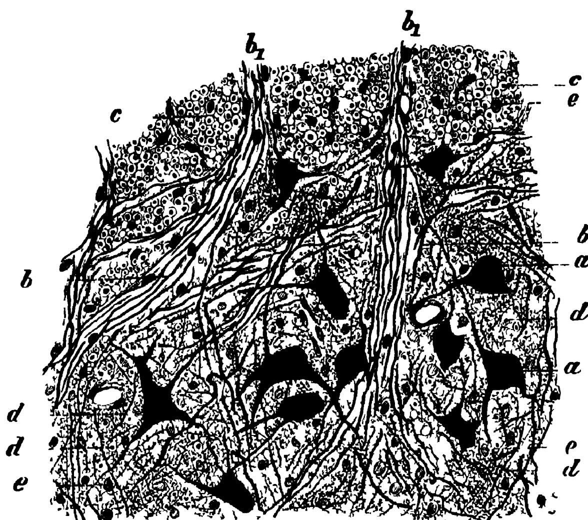


FIG. 257. LEFT ANTERIOR HORN (NORMAL) AT THE LEVEL OF THE FOURTH CERVICAL NERVE.

(*Hardened in Muller's fluid and alcohol, stained with haematoxylin and carmine, and mounted in Canada balsam:* ×150)

a multipolar ganglion-cells
b horizontal nerve-tracts within the grey matter
b_1 anterior roots
c cross-sections of nerves in the adjacent white matter
d nerve-fibres cut across more or less obliquely
e nuclei of neuroglia-cells

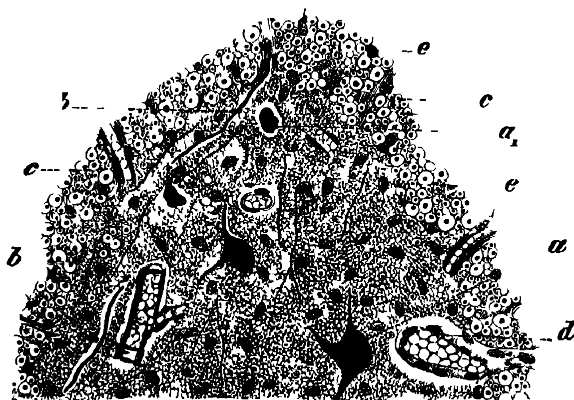


FIG. 258. LEFT ANTERIOR HORN (ATROPHIED) AT THE LEVEL OF THE FOURTH CERVICAL NERVE.

(*From a woman aged* 40 *who died of ascending atrophy of the anterior horns: prepared as above.* ×150)

a normal ganglion-cells
a_1 atrophied ganglion-cells
b intact nerve-fibres in grey matter
c cross-sections of nerves in adjacent white matter
d blood-vessel

and even this may be ultimately removed by absorption. At length all but a very few of the cells and fibres ($a\ a_1\ b$) disappear, and the anterior horn comes to consist chiefly of neuroglia.

Simple uncomplicated atrophy is not accompanied by any change of the connective tissue, and there is no trace of inflammatory mischief; moreover it is only when the nerve-fibres are involved and their medullary sheath is undergoing disintegration, that even granule-cells are detected, and these in very small number (Art. 638). Sometimes **secondary sclerosis** follows. Simple atrophy may therefore be described as a primary affection involving simple loss of the nervous elements of the grey matter of the anterior horn; it leads to atrophy of the anterior roots of the spinal nerves, and paralysis with atrophy of the muscles supplied by them. It may attack any portion of the anterior columns, but most frequently begins at the upper or the lower extremity and thence extends. In the former case the motor nuclei in the medulla are usually soon involved, while in the ascending forms this is naturally a late symptom. The sensory nuclei in the medulla and the posterior columns of the cord are in general unaffected.

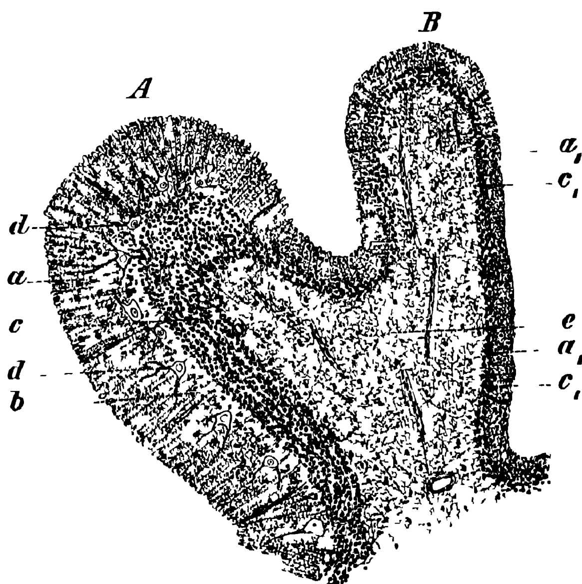


FIG. 259. ATROPHY OF THE CORTEX OF THE CEREBELLUM.

(From a man aged 25 who died in an epileptic fit: section hardened in Müller's fluid and alcohol, stained with haematoxylin and carmine, and mounted in Canada balsam: × 25)

A normal, *B* atrophied gyrus

a normal external layer
a_1 atrophied external layer
b normal intermediate layer
c normal, c_1 atrophied granular layer
d Purkinje's cells
e medullary (white) centre

This peculiar affection may thus be characterised as a simple disappearance of the ganglion-cells of the motor centres of the cord and medulla. When it extends over the greater part of the length of the cord it gives rise to a portion of the group of diseases spoken of as chronic atrophic spinal paralysis (*poliomyelitis anterior chronica*) and progressive muscular atrophy: when it involves the nuclei of the medulla it leads to some of the affections known collectively as chronic progressive bulbar paralysis and Duchenne's paralysis. Descending atrophy of the anterior horns is in general associated with degeneration in the pyramidal tract (Art. 647). When the atrophy begins in the lumbar cord this degeneration does not take place.

A similar disappearance of nerve-cells and nerve-fibres takes place both in the **basal ganglia** and in the **cerebral cortex.** When extensive it leads to a very marked loss of bulk in the parts affected. This loss of bulk is due partly to the entire disappearance, partly to marked dwindling, of the nerve-elements. In the cortex it is sometimes uniformly and widely diffused, sometimes in isolated patches.

The **white matter** like the grey is also liable to atrophy, which is either primary or secondary to atrophy of grey matter. When the bulk of a portion of the brain or cord is markedly diminished, the atrophic process extends to the white matter, and microscopic examination shows that some of the nerve-fibres in the latter have entirely disappeared while others have plainly undergone diminution of their thickness. In the disseminated or patchy form of atrophy the medullary white centre of the cerebrum often contains minute areas within which the tissue has a perforated or cribriform appearance; the nerve-fibres having disappeared a loose meshwork of neuroglia is all that remains. The adventitial lymph-spaces are in general dilated (Art. 637).

Atrophy of the laminae of the **cerebellum**, when it is at all marked, is chiefly due to thinning of the cortical layers, though the medullary centre also suffers in a less degree. As the cells and nerve-fibres disappear the external (or molecular) layer (Fig. 259 *a*) of the cortex is reduced to a third or a fourth (a_1) of its original thickness. The cells of Purkinje (*d*) and their processes disappear entirely, and with them the slender intermediate layer (*b*). Lastly the granular layer (*c*), losing its nerve-cells and fibres, becomes reduced to a mere film (c_1).

Loss of volume alone is not a certain mark of atrophy of the brain. Thus in infants suffering from chronic diarrhoea the brain may shrink so rapidly that the cranial bones overlap one another, but this is due in great measure simply to abstraction of liquid from the brain and its membranes.

Atrophy of the anterior horns of the cord can be certainly demonstrated only by examining a series of sections. The ganglion-cells are by no means uniformly distributed in different segments of the cord, and thus it may happen that a single section of a perfectly normal cord shows very few ganglion-cells, while neighbouring sections show them in abundance.

Many authorities speak of pigmentary atrophy of the ganglion-cells as distinct from simple atrophy; but it does not appear that there is ever any real or marked increase of pigment in the cases they describe. As ganglion-cells normally containing pigment become smaller the pigment does not disappear, and they accordingly seem to have more of it in proportion to their size. Non-pigmented cells scarcely ever exhibit any pigment as they atrophy. It must however be admitted that occasionally after the disappearance of the cells the amount of pigment seems to increase.

Atrophy of the large ganglion-cells of the anterior horns is followed by atrophy (**amyotrophy**) of the corresponding muscles; but all muscular atrophy is not dependent on loss of the ganglion-cells. ERB, SCHULTZE, and others have described cases in which after recent atrophy of the anterior horns of grey matter the anterior nerve-roots were still intact, though the muscles showed signs of degeneration. From this it would appear that the muscles perish more rapidly than the nerve-fibres. Many authors affirm that loss of the anterior ganglion-cells is accompanied by an increase of the neuroglia. This is occasionally the case, but by no means uniformly: very marked atrophy may be unattended by any such increase. It is worth mentioning that after the total disappearance of the nerve-elements from a section of the anterior horns small granular masses remain, interspersed among the cells and fibres of the neuroglia. This would go to show that the granular-looking substance of the grey matter does not belong wholly to the nerve-fibres and ganglion-cell-processes, a view recently re-affirmed by RANVIER (*Arch. de physiol.* I 1883).

Atrophy of the anterior horns with or without sclerotic change is often regarded as a chronic inflammation and described as *poliomyelitis anterior chronica*. In like manner ischaemic softening is sometimes regarded as a poliomyelitis. The genesis and course of these affections make it obvious that they are non-inflammatory and that such terms are inappropriate.

References on simple atrophy of the anterior horns and bulbar nuclei:—CHARCOT and JOFFROY, *Arch. de physiol.* 1869; PIERRET, *ibid.* II (1875); CHARCOT and GOMBAULT, *ibid.*; DUCHENNE and JOFFROY, *ibid.* IV (1870); CHARCOT, *ibid.*, *Diseases of the nervous system* London 1876—80; KESTEVEN, *St Barth. Hosp. Rep.* XIII (1878); SCHULTZE, *Virch. Arch.* vol. 75; CORNIL and LÉPINE, *Paralysie gén. spinale ant. subaigue*, *Gaz. méd. de Paris* 1875; JARISCH, *Viertelj. f. Derm. u. Syph.* VIII (1881); ERB and SCHULTZE, *Arch. f. Psych.* IX; VIERORDT, *ibid.* XIV; GOLTDAMMER, *Berl. klin. Woch.* 1876; DÉJÉRINE, *Arch. de physiol.* VI (1883); see also Art. 647, references on amyotrophic lateral sclerosis.

References on the structure of the cerebellar cortex and cerebellar atrophy:—DENISSENKO, *Arch. f. mikros. Anat.* XIV; OBERSTEINER, *Allg. Zeitschr. f. Psych.* vol. 27, *Biolog. Centralb.* III (1883); GOLGI, *Arch. ital. p. l. mal nerv.* 1874, *Rivista sperim. di freniatria* 1882, 1883; FIEDLER, *Zeitschr. f. rat. Med.* XI (1861); DUGUET, *Gaz. hebdom.* 1862; MEYNERT, *Med. Jahrb. d. Gesell. d. Aerzte in Wien* 1864; PIERRET, *Arch. de physiol.* IV (1871—72); E. CLAPTON, *Trans. Path. Soc.* XXII (1871); OTTO, *Arch. f. Psych.* IV; FISCHER, *ibid.* V; HUPPERT, *ibid.* VII; BISCHOFF, *ibid.* XII.

641. Some of the conditions included under the general term atrophy are directly dependent on **aplasia** or agenesis (Arts. 630 and 633) of parts of the brain and cord. Many atrophies detected only in years of maturity are in fact aplasias dating from the foetal period. Other atrophies affect nervous structures which have from the beginning been ill-developed or ill-organised. The greater number of cases of cerebellar atrophy (Art. 640) unassociated with inflammation or tumour certainly belong to this latter class, as do also those cases of shrinking of the cerebrum in which close examin-

ation of the convolutions and their structure shows that the atrophy coexists with local aplasias, such as partial defects of the gyri, etc. Atrophies of the cord, also, are frequently found associated with anomalies of its development.

When simple atrophy occurs without any visible cause in patients who have a family history of nervous disease, it is natural to suppose that the nerve-elements have had some intrinsic weakness of constitution which led to their premature decay and disappearance: and the same supposition is permissible even in cases where there is no such history.

GUDDEN and his pupils have shown that sensory as well as motor centres undergo atrophy and lose their ganglion-cells if at birth or in infancy the peripheral end-organs or nerves are destroyed. The explanation is perhaps this—that in the absence of the end-organ the corresponding central organ is not called on to perform its function and so wastes, or at least fails to attain to complete development.

Loss of peripheral end-organs in later life is only to a slight extent followed by similar atrophy. Thus after amputation of the limbs no marked changes take place in the cord, the number of ganglion-cells and nerve-fibres is apparently unaltered. In a few cases the corresponding half of the cord has appeared to become smaller, probably from thinning of the nerve-fibres. At the same time it must be kept in mind that in fifty out of every hundred persons the cord is more or less unsymmetrical (from incomplete decussation of the pyramids), and this makes it difficult to be sure that in a given case asymmetry is due to pathological causes.

Loss of the eye and optic nerve leads after a time in the human subject to atrophy of the corresponding parts of the optic tract. When blindness has lasted for a number of years the atrophy is said (HUGUENIN) to extend up to the occipital lobe.

Senile atrophy of the brain, which is not at all uncommon, seems to be due in the first place to mere outwearing and decay of the nerve-elements, and in part also to diminution of the natural nutritive processes (see KOSTJURIN and HESS, *Wiener med. Jahrb.* 1886). Cerebral atrophy in younger patients reduced and weakened by disease is doubtless due chiefly to disordered nutrition.

Localised atrophy of nerve-cells and fibres within particular circumscribed regions is at times demonstrably induced by atheromatous and hyaline thickening of the vessel-walls (Art. 642), or by occlusion and obliteration of the circumvascular lymph-channels from extravasation of blood or hyaline deposit. As regards the various forms of nervous atrophy met with in persons who have long suffered from disordered circulation, we must assume that the general cause has led to the particular effect. Disease of the heart or of the lungs, chronic inflammation of the meninges (Arts. 655, 656), and intracranial tumours, all act in this way; in the latter case local compression leading to local anaemia

(Art. 644) assists the more general causes. Lastly we must recognise as causes of atrophy the many injurious agencies which reach the central nervous system by way of the blood, and so damage its constituent elements. As examples we may mention lead (VULPIAN, DÉJÉRINE, MONAKOW, POPOW, and others), and alcohol when taken constantly and for a long time.

GUDDEN (*Arch. f. Psych.* II, *Graefe's Arch. f. Ophthalmologie* XX, XXI, XXV, *Naturforscherversammlung in Eisenach* 1882) was the first to show that the extirpation of peripheral or central end-organs in young animals is followed by atrophy of the corresponding central or peripheral end-organs respectively and of the conducting tracts. Thus extirpation of one cerebellar hemisphere induces atrophy of the restiform body and its three nuclei on the same side and the olivary body on the opposite side Extirpation of one anterior quadrigeminal body leads to blindness and proportionate wasting of the nerve-fibres of the optic tract on the opposite side. This method enables us to determine the central nuclei, the course, and the connexions of the various cerebral and spinal nerves, and the connexions between the nuclei of the cerebral axis, the cerebrum, and the cord. FOREL (*Arch. f. Psych.* VII), MAYSER (*ibid.*), GANSER (*ibid.* XIII), FURSTNER (*ibid.* XII), and MONAKOW (*ibid.* XII, XIII) have applied the method, and thereby greatly increased our knowledge regarding the nuclei and tracts of the cerebral axis. MONAKOW (*Arch. f. Psych.* XII) showed that extirpation of the visual centre in the occipital cortex in new-born rabbits is followed by **atrophy** of almost the entire **visual tract**, *i.e.* the corresponding part of the corona radiata (optic radiations of Gratiolet), the external geniculate body, the lateral (latticed) stratum of the external nucleus of the thalamus, to a less extent the anterior quadrigeminal body of the same side, the chiasma, and the opposite optic nerve. Extirpation of the eyeball leads to atrophy of the same parts, most marked however in the optic nerve of the same side and in the anterior quadrigeminal body of the opposite side. According to HAAB a like atrophy or rather aplasia is met with in cases of anophthalmia.

Our knowledge of the secondary degenerations of the visual tract is however still very defective, and minute investigation of the histological changes involved is much to be desired. Probably the first change is a disintegration of the medullary sheath of the nerve-fibres (Art. 646): the axis-cylinder appears to persist for a time. GUDDEN, SCHMIDT-RIMPLER, PURTSCHER, SAMUELSOHN, BAUMGARTEN, MARCHAND, and others have shown that atrophy of the optic nerve is after a time accompanied by wasting of the decussating bundles of fibres on the inferior or ventral aspect and of the non-decussating bundles on the dorsal aspect of the optic tract. We do not yet know how far this process of wasting may extend. SAMUELSOHN followed it up to the external geniculate body: HUGUENIN states that it extends to the occipital lobe. The descending atrophy induced by destruction of the visual centre in the cortex (hemianopsia) has not been fully investigated. LEBER thinks that in adults the trunk of the optic nerve does not atrophy after a cortical lesion, and only after a period of years when it is the optic tract that is destroyed. HOSCH (*Klin. Monatsbl. f. Augenheilk.* XVI) alone seems to have actually observed atrophy of the optic nerve after destruction of the occipital lobe. It would appear from what we have said above that in the case of the optic nerve we may have an ascending atrophy, but the like has not been observed in the case of other sensory nerves. The only analogue is apparently the atrophy of the posterior columns of the cord observed to follow destruction of the posterior nerve-roots, and we might add the instance of ascending atrophy of the auditory nerve extending to the temporal lobe, which HUGUENIN describes as having occurred in a patient who had been deaf for many years.

References on ascending atrophy of the visual tract :—LEBER, *Graefe and*

Saemisch's Handb. v; GUDDEN, *Arch. f. Ophthalm.* 1879; HAAB, *Beiträge z. Ophthalm., Festschrift für Horner* Wiesbaden 1881; KELLERMANN, *Beilage z. klin. Monatsbl.* 1879; PURTSCHER, *Graefe's Arch. f. Ophthalm.* XXVI (1880); SAMUELSOHN, *Berl. klin. Woch.* 1880; BAUMGARTEN, *Cent. f. med. Wiss.* 1878; MARCHAND, *Graefe's Arch.* XXVIII; MAUTHNER, *Gehirn und Auge* Wiesbaden 1881; DRESCHFELD, *Brain* IV (1882).

On hemianopsia and destruction of the cortical visual centre see Art. 625.

DICKINSON (*Journ. of Anat. and Physiol.* III 1868), DRESCHFELD (*ibid.* XIV 1880), VULPIAN (*Arch. de physiol.* 1868), LEYDEN (*Klinik d. Rückenmarkskr.* II), DÉJÉRINE and MAYER (*Gaz. méd. de Paris* 1878), and others have described cases of atrophy of the motor and sensory centres and tracts in the cord after **amputations** of the limbs. Objections may be taken to some of their statements, but it would appear that the posterior roots, posterior horns, and posterior columns may occasionally atrophy: the ganglion-cells and nerve-fibres do not disappear outright but become abnormally small and thin.

It is questionable whether in persons who in adult life have lost a limb the corresponding centres in the cortex ever undergo atrophy. SANDER (*Cent. f. med. Wiss.* 1875), LUYS (*Gaz. des hôp.* 1876), BOURDON (*Recherches clin. sur les centres mot. des membres* Paris 1877, *Bull. de l'acad. de méd.* XII 1883), and others have described such cortical atrophies, but it must be remembered that the width of the convolutions varies greatly even in persons otherwise normal. CHARCOT, FERRIER, and others have failed to find unmistakeable instances. DAVIDA (*Virch. Arch.* vol. 88) and EDINGER (*ibid.* vol. 89) have found that when limbs are congenitally absent there is atrophy of the spinal nerve-roots, the corresponding grey matter, and the lateral columns of the cord, and in some cases (EDINGER, GOWERS) even of the corresponding cortical centres.

VULPIAN (*Maladies du syst. nerv.* Paris 1879), DÉJÉRINE (*Gaz. méd. de Paris* 1879), MONAKOW (*Arch. f. Psych.* X 1880), POPOW (*Virch. Arch.* vol. 93), and others state that in paralysis from **lead-poisoning** there is degeneration not only of the muscles and peripheral nerves but also of the ganglion-cells of the cord and brain. It does not appear certain that lead gives rise to any primary atrophy of the central nervous system, though apparently there is no doubt that in lead-poisoning the brain may contain a large proportion of the metal, and that the affection may be accompanied by grave and chronic mental disorder. For references see ROSS, *Diseases of the nervous system* II London 1883, and ROBINSON, *Brain* VIII 1885.

642. **Ischaemic and haemorrhagic softening.** The vessels of the brain and cord are peculiarly liable to morbid changes. Sclerosis and atheroma are more common in them than in those of almost any other organ, while the small arteries and capillaries of the central nervous system and its membranes might almost be called the favourite seat of hyaline degeneration. Fatty and calcareous change are exceedingly common, the latter being sometimes so extensive and so great that on section the vessels stand out from the brain-substance as little rigid tubes. Moreover corpuscular matters passing from the heart into the arterial system, and atheromatous detritus or fibrinous coagula from the ascending aorta, are very readily swept through the cervical into the cerebral arteries.

The consequence is that it is very common for the arteries of the brain or cord to be suddenly or gradually occluded, the accident being followed by grave disturbance of the circulation and nutrition of the corresponding regions.

The arteries of the brain and cord have no arterial anastomoses within the nerve-substance, and thus after the closure of one of them collateral circulation is very slowly and imperfectly established. This is especially the case when the neighbouring arteries are already rigid and obstructed by atheromatous or hyaline change in their walls

Engorgement, stasis, and haemorrhage all lead to local anaemia or **ischaemia** of the particular regions affected. Haemorrhage need not be at all large; even the smallest extravasations, confined it may be to the pial sheaths of the vessels, have their effect,

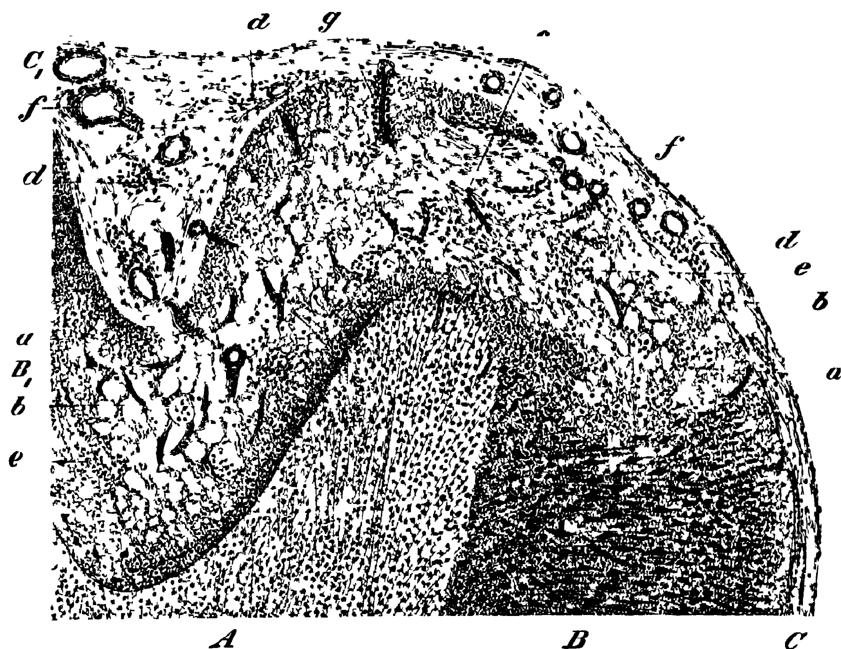


FIG. 260 ISCHAEMIC SOFTENING OF THE CORTEX OF THE BRAIN.

(*From the brain of an idiot hardened in Muller's fluid and alcohol, stained with haematoxylin and carmine, and mounted in Canada balsam* × 25)

A white centre *B* normal cortex
C normal pia mater C_1 thickened pia mater

a softened part of cortex without ganglion cells, the neuroglia still remaining in places
b part with little but the capillary network remaining
c condensed fibrous-looking tissue
d groups of cells in the subpial and subarachnoid spaces
e patch containing leucocytes, fat-granule cells, and pigment cells
f small blood vessel
g groups of cells in the circumvascular spaces

and other matters, such as products of disintegration, when they collect in these sheaths may by compression render the vessel impermeable to the circulation.

Lastly, compression of the nerve-substance by tumours, exudations, etc. (Art. 644) leads frequently to local anaemia or ischaemia.

When such temporary or permanent ischaemia gives rise to necrosis of the substance of the brain or cord, **softening** of the necrosed region speedily takes place. If the ischaemia is unaccompanied by haemorrhage the tissue remains pale and at first only becomes softer and more brittle: this process is therefore described as **white softening**.

After a few days the substance of the organ is (owing to the rapid disintegration of the nerve-elements and the escaped liquid from the vessels) transformed into a pulpy mass, containing the products of disintegration described in Art. 638 together with fat-granule cells of every conceivable form.

In the course of weeks the process of liquefaction steadily advances, and at length nothing remains of the nerve-substance but a liquid mass rendered turbid by detritus and fat-granule cells. The blood-vessels usually persist (Fig. 254 *c*, Fig. 260 *b*), and thus the liquid appears as if lodged in the meshes of a delicate network of capillaries. After some months the liquid becomes clear, owing to the absorption of the products of disintegration.

Around the patch of softening the neuroglia proliferates and gives rise to **sclerotic thickening**, though this is seldom very marked. It is most apt to occur when the patch is small, the patient young, and the softening not due to arterial sclerosis. Often after weeks or months no considerable proliferation is discoverable, the softened patch being surrounded by a zone in which the nerve-elements are in process of degeneration and the tissue accordingly more or less interspersed with granule-cells.

The vessels within the softened patch become in part obliterated. Cellular and fibrous hyperplasia sometimes takes place in the pial sheaths both of the collapsed and of the permeable vessels.

When haemorrhage accompanies the ischaemic softening the products of disintegration of the extravasated blood mingle with those of the nerve-substance and give the patch a red, yellow, rusty, or brown tint. The process is then described as **red** or **yellow softening**. The mass thus contains pigment-granule cells, and after a time flakes of yellow or brown pigment and occasionally crystals of haematoidin are deposited in the surrounding tissue.

On ischaemic softening see EISENLOHR (*Arch. f. Psych.* IX 1878, on acute affections of the medulla and pons), KLEBS (*Prag. med. Woch.* 1879).

On hyaline degeneration of cerebral vessels see WEDL (*Wiener Sitzungsber.* XLIII 1863), ARNDT (*Virch. Arch.* vol. 49), LUBIMOFF (*ibid.* vol. 57), BENEDIKT (*ibid.* vols. 64, 72), KOLESSNIKOW (*ibid.* vol. 85), NEELSEN (*Arch. d. Heilk.* XVII 1876), OTTO (*Arch. f. Psych.* XVI, on aneurysms of the vessels of the cord), and references in Art. 636.

643. The size of a patch of softening depends on that of the vascular territory which has been deprived of blood, and consequently

varies much in different cases. The smallest patches may be too small for the unaided eye, the larger may involve whole convolutions, important sections of the centrum ovale or of the basal ganglia, or even entire lobes.

The smaller patches after a time take the form of little cavities filled with clear liquid, and when numerous give the tissue a cribriform or sponge-like appearance. When the softening has occurred round a small arterial branch the space left vacant on absorption of the products of disintegration is often filled up by accumulation of liquid in the adventitial lymph-channel belonging to the vessel, which latter then looks as if it ran through a wide lymph-sac resembling that caused by simple localised lymphatic stagnation or engorgement. The condition in which the nerve-tissue is thus as it were riddled with small cavities is commonly described as an *état criblé* (compare also Art. 637).

The contents of large **cysts of disintegration** due to ischaemic softening are seldom quite clear, the absorption of the solid detritus being a very slow process, while at the borders of the softened region the disintegration of nerve-substance usually goes on to some extent for months or years after the initial lesion.

When such large cysts lie just under the pia mater or at least not very deeply, the overlying tissue in general sinks in and leaves a subpial or subarachnoid space which soon fills with liquid. The depressed surface looks opaque and white or tinged with yellow or brown. On section the softened patch is found to contain a milky (or sometimes pigmented) liquid traversed by shreds of tissue which are for the most part collapsed or still permeable vessels and capillaries (Fig. 260 B_1).

The membranes overlying an old patch of softening are usually hyperplastic (C_1), the blood-vessels also often showing signs of thickening (f). A certain amount of cellular infiltration takes place not only into the walls of the cyst but also into the soft membranes (pia mater and subarachnoid), and this may continue as long as the process of disintegration goes on. Calcareous concretions are not infrequently formed in the thickened membranes, and the ganglion-cells in the parts contiguous to the cyst may also become calcified. When a patch of softening lies near a ventricle the latter usually becomes dilated by the falling away of its wall in the direction of the cyst of disintegration.

Ischaemic softening occurs at all parts of the central nervous system: in the brain the process is named briefly **encephalomalacia**, in the cord it has been called **myelomalacia**.

Softening of the cord affects the grey matter, the white matter, or both together. It is interesting to observe that the anterior horns are more liable than the other regions to undergo anaemic and haemorrhagic softening: the anterior horn corresponds almost exactly with the vascular territory of one of the arterial twigs entering by the anterior longitudinal fissure, and when the

circulation in it is suspended almost all the motor ganglion-cells in the corresponding half of the spinal segment must suffer.

Any part of the basal region of the brain may be the seat of softening, and the disorders of function thus induced are of the most various kinds. Occurring anywhere in the pyramidal (or motor) tract it leads to motor paralysis which is usually unilateral (hemiplegia): in the neighbourhood of the bulbar nuclei or the conducting paths leading from them it gives rise to paralysis of one or more of the cranial nerves.

In the cerebrum softening occurs in the territory of the basilar or of the cortical arteries. Destruction of cortical centres thus brought about results in various motor and sensory paralyses. Thus destruction of the angular gyrus and occipital lobe implies loss of vision, destruction of the central convolutions and parietal lobe causes paralysis of the limbs on the opposite side, destruction of the left inferior-frontal convolution in right-handed persons induces motor aphasia, and so on. If the number of patches of cortical softening (Fig. 260) be great, almost all the functions of the brain may be more or less impaired.

Large and single or small and multiple softenings occurring in the corona radiata or internal capsule lead to interruption of the motor tract and consequently to motor paralysis.

Localised softening in the anterior horns of the cord is followed by paralysis of special groups of muscles. Thus in a recent case observed by the author the muscles of one arm were paralysed, in another one arm and the diaphragm; on examination patches of softening were in each case found in the anterior horn of the middle and lower portions of the cervical cord on the same side. Such ischaemic softenings of the anterior horn are frequently misdescribed by clinical observers as due to anterior poliomyelitis. EHRLICH and BRIEGER (*Zeitschr. f. klin. Med.* 1884) found that after temporary ligature of the aorta, by which the lumbar cord was deprived of blood for an hour, the grey matter and the anterior roots were completely degenerated, the white columns still remaining intact.

644. **Softening from compression.** When the substance of the brain or cord is in any way subjected to severe compression, degeneration of the compressed tissue sooner or later sets in. Such compression is most frequent in the case of the cord, every encroachment on the narrow spinal canal involving almost of necessity a pressure on the soft tissue which it cannot escape. For example, tuberculous granulations, caseous matter and pus collecting in the epidural space during inflammatory disease of the vertebrae, tumours of the bone, dura mater, or pia mater, haemorrhagic effusion into the membranes, varicosities or angiomatous overgrowth of the pial vessels, dilatations of the central canal of the cord itself, dislocation of the vertebrae such as occurs in caries of the spine, all give rise to compression of the nerve-substance.

Loosening or rupture of the ligaments connecting the axis and atlas, such as occurs in carious disease of the upper cervical spine

or occiput, or a blow on the back of the head or neck, may cause the odontoid process of the axis to press upon the medulla oblongata.

The injurious effect of sudden or gradual compression of the cord, apart from any mechanical damage of the tissues, is doubtless due in great measure to disturbance of the circulation, leading to more or less protracted anaemia of the nerve-substance. When this reaches a certain degree of intensity and duration anaemic necrosis and softening are induced. In like manner if the outflow of blood be hindered by the compression we have haemorrhage from venous engorgement. The white matter is the first to soften; the grey matter usually persists for a time, its blood-supply being derived not from the periphery but from the vessels of the longitudinal fissures. According to KAHLER six hours after compression the axis-cylinders begin to swell up to such a degree that they sometimes seem to distend and stretch the meshes of the neuroglia. After the second day they begin to disintegrate, often becoming vacuolated in the process.

In the first week or two after compression the substance of the cord is white and opaque owing to the quantity of nerve-detritus which is present. Then it becomes more translucent, and at length grey and gelatinous, as the products of disintegration are absorbed. At the same time hyperplasia of the neuroglia sets in, and continues for some months, until the tissue is very considerably increased in amount and in density (Art. 639, Fig. 256). If the haemorrhage has taken place during the process of softening the grey sclerotic tissue is more or less visibly pigmented.

Compression of the brain differs in its conditions from that of the cord much as the cranial cavity differs from the spinal canal. Thus if a meningeal tumour slowly encroaches on the space within the cranial cavity room is made for it by an efflux of lymph or cerebrospinal liquid from the brain, the latter so far altering its form as to become indented where the growth presses on it. The brain-substance remains uninjured unless the tumour is of considerable size: in this case it may cause a localised simple or degenerative atrophy. Degeneration is more common in cases of tumour growing within the brain, or of chronic cerebral abscesses, which by pressure on the sound tissue give rise to disturbance of the circulation.

Sudden encroachments are apt to damage the brain-substance, such for instance as are caused by haemorrhages, or inflammatory exudations into the meninges or ventricles. Even sudden congestive hyperaemia may give rise to dangerous intracranial pressure.

Increased afflux of blood to the brain, inflammatory exudations, and haemorrhagic effusions determine in the first instance an outflow of cerebrospinal liquid from the cranium into the spinal canal: sometimes indeed the liquid displaced is so abundant that the intervertebral ligaments bulge under its pressure. When however the

intracranial pressure reaches a certain point no further displacement can take place, the capillaries of the brain are compressed, the circulation comes to a stand-still, and the impaired nutrition of the nerve-elements results in impairment of their functions. If the pressure is not quickly relaxed by re-absorption of the effusion or by efflux of blood, so that the circulation is restored, and death does not at once ensue, extensive degenerative changes may take place in the parts first compressed. In remoter parts the pressure relaxes as the first give way. Thus it is very common to find a zone of softening immediately surrounding an extravasation of blood or an effusion into a ventricle, but not extending to any great distance.

References:—ERB, *Ziemssen's Cyclopaedia* XIII; LEYDEN, *Klinik d. Rückenmarkskrankh.* 1874—76; KAHLER and PICK, *Arch. f. Psych.* X; CHARCOT, *Diseases of the nervous system* II London 1880, *Gaz. méd.* 1874; BOUCHARD, *Dict. ency. d. sciences méd.* (second series) VIII; MICHAUD, *Sur la myélite et la méningite dans les mal. vertébr.* Paris 1871; BERGMANN, *Deutsche Chirurgie* part 30, 1880; KAHLER, *Prag. Zeitschr. f. Heilk.* III; ADAMKIEWICZ, *Wien. Sitzungsber.* XLVIII 1883, *Wiener Klinik* VIII, IX (1884); WERNICKE, *Fortschritte d. Med.* III 1885.

KAHLER experimented on compression of the cord by injecting melted wax into the spinal canal. Sclerosis resulted only after several months.

645. **Softening from contusion and concussion.** When the substance of the brain or cord is contused or crushed, or even violently shaken, it frequently undergoes complete and rapid necrosis and ultimately disintegrates.

A moderately abundant spontaneous haemorrhage may have this effect, but among mechanical causes the commonest are dislocation and fracture of the vertebrae, blows or falls on the head (concussion), cuts or stabs penetrating the bony coverings of brain or cord, and projectiles reaching the central nervous tissues. Splinters of bone, such for example as occur in depressed fracture of the skull, should also be included.

The death of the nerve-substance is doubtless due to the direct injury to its elements and the rupture of their connexions, and in part to the disturbance of the circulation and consequent failure of nutrition.

When the injury is very extensive it may speedily result in death. Where the contusion is less severe, as is the case of a blow on the head, the part directly injured or even the entire brain is the seat of capillary haemorrhage, so that on section it appears mottled or speckled with spots of red. Extreme violence may cause immediate disintegration of the tissue, so that it becomes a mere mass of *débris* and blood. Meningeal haemorrhage is an almost invariable accompaniment.

The changes resulting from traumatic destruction of the nervous tissues, provided septic inflammation is excluded, exhibit the characters partly of anaemic and partly of haemorrhagic necrosis. Liquefaction and absorption of the products of disintegration ensue, the process not being essentially different from that described in

connexion with ischaemic necrosis, though the subsequent inflammatory changes are apt to be somewhat more intense than in the latter case (Art. 658). If the traumatic softening is confined to the cortex of the brain, we find some time afterwards defects in the convolutions, which are covered over by a mass consisting of collapsed capillaries, unabsorbed detritus, and granule-cells. Sometimes sclerotic thickening of the underlying brain-tissue takes place.

It is worth remarking that the degenerative changes set up by traumatic violence such as we have just described occasionally go on for years after the initial injury, and that a gradually advancing disintegration of the borders of the softened region takes place, by which in the course of time a very extensive destruction of tissue is effected. Thus for example after a blow on the forehead the whole of the frontal lobe may perish. Probably this progressive destruction depends on some secondary disease of the blood-vessels or obstruction of the lymphatics, which gives rise to permanent disorder of circulation and nutrition.

If the effect of the initial injury is slight there may be no general disintegration of tissue, the damage perhaps not extending beyond the necrosis and calcification of a few ganglion-cells.

The changes in the cord are exactly similar to those in the brain under the same conditions (Art. 659).

The clinical symptoms of concussion of the brain and cord (*commotio cerebri et medullae spinalis*), namely partial or total loss of consciousness, confusion of mind, muscular weakness, disorder of the functions of the cord, etc. are not dependent on the local damage alone. Even in rapidly fatal cases this damage may be but slight. There is in fact a disturbance of the functions of the entire organ, due doubtless to the mechanical shock which affects detrimentally the whole of the nerve-substance (KOCH, FILEHNE, WITKOWSKI, BERGMANN).

In infants who die soon after birth we often meet with subdural and intrameningeal haemorrhages, due no doubt to rupture of the venous sinuses or subarachnoid veins from displacement and compression of the cranial bones in the act of parturition.

Workmen engaged in bridge-building and exposed to high air-pressure in sunken caissons are sometimes seized with paralysis when they come out suddenly into the free air. LEYDEN (*Arch. f. Psych.* IX) found in some of them small patches of degeneration in the cord. These he attributes to the rapid escape of gas (oxygen) from the blood, which had under high pressure absorbed it in excess, the bubbles probably forming small emboli in the vessels.

References:—BERGMANN, *Kopfverletzungen*, *Deutsche Chirurgie* part 30, 1880; FISCHER, *Sammlung klin. Vortrage* 10, 27; BRUZELIUS and KEY, *Virchow's Jahresber.* II (1880); FRONMULLER, *Die Rückenmarkszerreissung*, *Memorabilien* 1876; W. MULLER, *Path. Anat. u. Physiol. d. Rückenmarks* Leipzig 1871; ERB, *Ziemssen's Cyclopaedia* XIII; CLEMENS, *Die Erschütterung d. Rückenmarks*, *Deutsche Klinik* 1863—65; OBERSTEINER, *Wiener med. Jahrb.* 1879; VON RECKLINGHAUSEN, *Virch. Arch.* vol. 30; JOLLY, *Stud. a. d. Inst. f. exp. Path.* Vienna 1870; KRAFFT-EBING, *Die d. Gehirnerschutt. u. Kopfverletzungen hervorgerufenen psych. Krankh.* Erlangen 1868; KOCH and FILEHNE, *Langenbeck's Arch.* XVII (1874); WITKOWSKI, *Virch. Arch.* vol. 69.

646. **Secondary degenerations of the tracts** (systemic degenerations). Destruction of certain parts of the brain and cord

is followed by a degeneration of certain corresponding tracts of nerve-fibres, which is called secondary degeneration. It is probably due to the fact that the affected tracts are severed from their 'trophic centres,' or that these latter are destroyed. We have ascending and descending secondary degeneration, according to the direction in which the process advances.

Descending degeneration is commonest in the pyramidal tracts (Art. 626, Fig. 246 *Pvb Psb*), and takes place in all cases in which the motor centres of the cerebral cortex are destroyed, or in which the motor tract as it passes through the corona radiata, the internal capsule, the peduncular region, or the pyramidal columns, is anywhere interrupted. The degeneration extends down to the points at which the motor fibres leave the anterior horns of the cord. In rare cases the ganglion-cells of the anterior horns also are atrophied, and then the motor fibres in the anterior roots of the spinal nerves become degenerate. When the destruction of the cortical centres is incomplete or only superficial it is not usually followed by secondary degeneration. It must however be borne in mind that in insane paralytic patients, in whom extensive superficial atrophy of the motor region of the cortex has resulted from chronic inflammation, we meet with degeneration of the pyramidal tract: this is however probably a secondary disease of the cord rather than a secondary degeneration in the strict sense of the term (Art. 647).

When the primary disease is in the cord, and such that the motor tract is entirely interrupted, the anterior pyramidal tract below the affected section becomes atrophied, but only for a distance of one or two centimetres, a few fibres perhaps showing degenerative change for a greater distance. In the case of the posterior columns of Burdach the degeneration extends downward along some fibres as much as six centimetres. The latter are perhaps fibres which enter with the posterior roots and then pass downwards for a certain distance in the substance of the cord (SCHULTZE).

According to CHARCOT when the anterior portion of the internal capsule is destroyed secondary degeneration appears in a bundle of fibres passing through the middle of the crustal stratum of the crus to the pons and probably ending in some of the nuclei of the medulla.

Ascending degeneration follows upon destruction of the cord or of the posterior root-fibres of the spinal nerves.

If the cord is cut across all the posterior tracts degenerate for a short distance above the point of section, the columns of Goll (Fig. 246 *fgr*) alone degenerate for a greater distance, namely up to the nucleus of the funiculus gracilis. Destruction of the posterior roots has the like effect. It is thus rendered probable that the columns of Goll have their trophic centre in the spinal ganglion-cells.

If the cord is cut in the upper dorsal region the direct

cerebellar tracts (Fig. 246 *Ksb*) above the lesion become degenerate: they pass from the vesicular columns (of Clarke) to the cerebellum. According to SCHULTZE a small region of the lateral column near the periphery also undergoes atrophy.

Secondary degeneration occurs chiefly after ischaemic softening, atrophy from compression, and haemorrhagic or inflammatory destruction of the tracts and centres indicated. It does not always follow upon sclerosis of the cord or brain, inasmuch as the conducting tracts are apparently not always entirely interrupted in passing through sclerotic patches.

The degeneration takes place simultaneously over the whole extent of the affected tract. It is recognisable under the microscope in the second week after the initial lesion, disintegration of the medullary sheath and axis-cylinder of the nerve-fibres having by that time begun. When it has advanced to a certain point absorption of the products of disintegration begins, and the familiar granule-cells make their appearance. The space vacated by the atrophied fibres is filled up partly by effusion of liquid, partly by hyperplasia of the neuroglia, though it may be months or years before the latter becomes fairly dense and compact (Art. 639, Figs. 255, 256).

So long as the degenerate tracts contain abundance of detritus they are white, opaque, and soft. As absorption goes on they become grey and translucent; when sclerosis takes place they become firm, and at the same time shrink in volume.

In the text we have spoken only of total secondary degeneration of the longitudinal tracts of the brain and cord. Of course particular bundles of fibres may likewise undergo degeneration, and even the short transverse or commissural fibres of the cord. SCHULTZE met with a case of traumatic injury to the sciatic fibres in the lumbar cord, in which only the posterior portions of the columns of Goll were atrophied. Nerve-tracts degenerate from the initial lesion up to the next terminal organ, and apparently in the direction of normal conduction. Some of the fibres of the cord however do not degenerate in either direction after an interrupting lesion (FLECHSIG).

BOUCHARD and SCHIEFFERDECKER found secondary degeneration 14 days after lesion, W. MULLER 13 days, and KAHLER and PICK 11 days.

References:—TURCK, *Zeitschr. d. Gesell. d. Aerzte in Wien* 1850, *Wiener Sitzungsber.* VI (1851), XI (1853); WALLER, *Muller's Arch.* 1852; WESTPHAL, *Arch. f. Psych.* II; SIMON, *ibid.* V; LEYDEN, *Deutsche Klinik* 1863, *Klin. d. Rückenmarkskr.* II; BOUCHARD, *Arch générales* 1866; GUDDEN, *Arch. f. Psych.* II (1869); CHARCOT, *Diseases of the nervous system* London 1878—80, *Leçons sur la localis. dans les mal. d. cerveau* I Paris 1878—80, *Progrès méd.* 1879; FLECHSIG, *Die Leitungsbahnen* Leipzig 1876, *Arch. d. Heilk.* XVIII (1877), *Ueber Systemerkrankungen* Leipzig 1878; SCHULTZE, *Cent. f. med. Wiss.* 1876; *Virch. Arch.* vol. 79, *Arch. f. Psych.* XIII, XIV; MEYER, *ibid.* XIII; KAHLER and PICK, *ibid.* X; BINSWANGER, *ibid.* XI; SCHIEFFERDECKER, *Virch. Arch.* vol. 67; HAYEM, *Arch. de physiol.* V (1873); HOMÉN, *Virch. Arch.* vol. 88, *Fortschritte d. Med.* III (1885); ERB, *Ziemssen's Cyclopaedia* XIII; NEELSEN, *D. Arch. f. klin. Med.* XXIV (1879); FERRIER, *Localisation of cerebral disease* London 1878, *Trans. internat. med. congress* I London 1881; BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884; BARTH, *Arch. d. Heilk.* X; MULLER, *Path. Anat. d. Rückenm.* 1871; ISARTIER, *Des dégén. second. de la moëlle épin. conséc. aux lésions du cerveau* Paris 1878; LÖWENTHAL, *Fort-*

schritte d. Med. I (1883); MENDEL, *Neurolog. Centralb.* I (1882); MARTINOTTI, *Sulle degen. sistem. del midollo spin. second.*, *Collezione ital. di medicina* (3rd series) 11 and 12, 1885; LANGLEY, *Brain* VIII 1886.

647. **Primary scleroses of the columns of the cord.** Primary sclerosis or grey degeneration is a change extending over entire tracts or columns of the spinal cord: it resembles secondary degeneration in its course and results, differing from it however in the apparent absence of any interrupting lesion of the conducting paths.

Its essential characters are degeneration of the nerve-fibres and hyperplasia of the connective tissue (sclerosis), but the relations of these are somewhat different from those observed in secondary degeneration. Disintegration of the nerve-elements and increase of the neuroglia begin almost simultaneously and go on side by side: indeed some have regarded the neurogliar hyperplasia as the primary disorder and the degeneration of nerve-substance as secondary to it. There is however no real doubt that the degeneration is the primary and essential feature of the disease.

The medullary sheaths are the first to disintegrate, and then the axis-cylinders; the degenerating tract thus loses in succession a number of its fibres, greater or less according to the duration of the affection (Fig. 261). Fat-granule cells (*b e*) appear, as in all

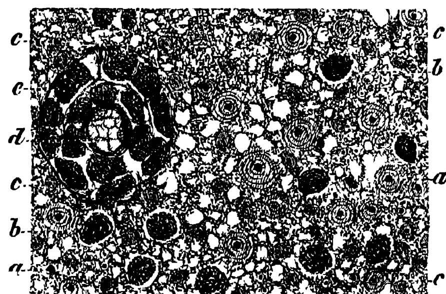


FIG. 261. SCLEROSIS OF THE POSTERIOR WHITE COLUMNS OF THE CORD.

(*Section treated with Müller's fluid, haematoxylin, carmine, and perosmic acid, and mounted in glycerine:* × 150)

a section of normal nerve-fibres
b granule-cells
c neuroglia with nuclei
d blood-vessel
e granule-cells in the lymph-sheath of the vessel *d*

nerve-degenerations, and accumulating chiefly in the lymph-sheaths (*d*) of the vessels are carried off by these channels. While this is going on the cells of the neuroglia (*c*) begin to multiply, and as the nerve-elements dwindle and disappear the connective tissue increases and fills their places. Thickening of the vessel-walls also takes place.

Sclerosis is commonest in the posterior columns of the cord,

and is the anatomical basis of the disease known as **tabes dorsalis** or locomotor ataxy.

In advanced cases the degeneration and sclerosis may extend over the entire section of the posterior columns in the dorsal region of the cord (Fig. 262). In the lumbar region (Fig. 263) the anterior portion of the section is almost always exempt. In the cervical region (Fig. 264) two lateral segments of the anterior portion are spared or but slightly affected. The changes are

Fig. 262.

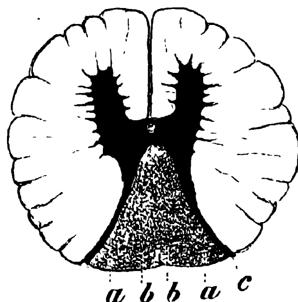


Fig. 263.

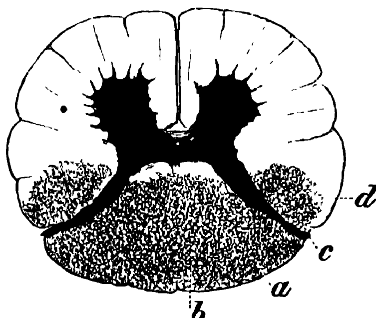


Fig. 264.

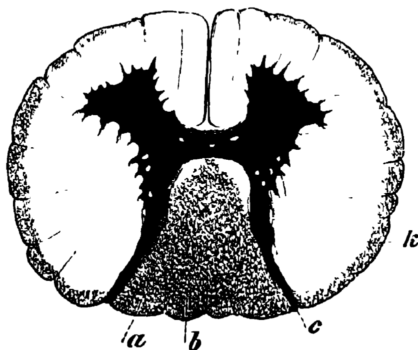


Fig. 262. Complete sclerosis of posterior columns and atrophy of posterior roots.

(*Section through dorsal region:* × 5)

a cuneate fasciculus
b column of Goll
c atrophied posterior root

Fig. 263. Sclerosis of posterior and lateral columns.

(*Section through upper lumbar region:* × 5)

a cuneate fasciculus
b column of Goll
c atrophied posterior root
d posterior portion of lateral column

Fig. 264. Sclerosis of posterior columns and of marginal region.

(*After* WESTPHAL: *section through cervical region:* × 5)

a cuneate fasciculus
b column of Goll
k marginal sclerosis along direct (or lateral) cerebellar tract

usually (unless the degeneration is universal) most marked in the lumbar and dorsal regions, though cases occur in which the cervical region is the most affected. The degeneration ascends within the columns to beyond the obex of the calamus scriptorius and ceases about the level of the *striae acusticae* (Fig. 248, Art. 629).

When the degeneration of the posterior columns is well-advanced their outer surface assumes a grey or greyish-red tint, and on section the tissue appears quite grey and translucent. At the same time the columns appear somewhat shrunken.

The posterior nerve-roots are always more or less atrophic and grey, the atrophy being greatest when the general degeneration is most advanced. The posterior root-fibres within the cord are likewise atrophic; and not alone those which pass forward through the substance of the posterior columns but also those which traverse the posterior root-zones. In rare cases some of the ganglion-cells of the grey matter are destroyed.

This degeneration of the posterior columns with the accompanying changes in the posterior roots is usually an independent and uncomplicated malady: but cases occur in which simultaneously or subsequently portions of the lateral columns also undergo degeneration (Fig. 263 *d*).

The portions most apt to be invaded are the posterior (pyramidal tracts) and the marginal (direct cerebellar tracts, Fig. 264 *k*): sometimes the marginal sclerosis extends right round to the anterior columns.

A second form of primary degeneration is that known as **amyotrophic lateral sclerosis**. It is essentially a degeneration of the lateral columns extending over the whole length of the cord, and accompanied by atrophy of the ganglion-cells of the anterior horns and the equivalent grey nuclei in the medulla.

The degeneration of the white matter is marked by atrophy, disintegration, and disappearance of nerve-fibres, together with increase of connective tissue, though the sclerotic induration is not usually so extreme as in the corresponding affection of the posterior columns. Only when the disease has lasted a very long time does the new fibrous tissue become dense and compact.

In many cases the degeneration is limited to the lateral pyramidal tracts (Fig. 265 *b*): and thus where these tracts have a well-marked contour on section, namely in the cervical region, the disease is also sharply defined; where they are interpenetrated by other systems of fibres and extend forwards, as in the dorsal region, it is difficult to make out the exact extent of the disease. If the pyramidal tracts have decussated completely at the medulla, the degeneration is confined to the lateral columns (Fig. 265 *b*); but if some of the strands are undecussated then the anterior (or uncrossed) pyramidal tracts are also affected. In other cases again the short tracts in the anterior-lateral columns variously described as principal tracts (FLECHSIG) and anterior root-zones (CHARCOT)

undergo a like change. These tracts connect the various segments of the cord with each other and with the medulla, and include root-fibres which run longitudinally for a certain distance within the cord before passing out with the roots.

The direct cerebellar tracts are invariably exempt. In an ascending direction the disease has been traced up to the pons and crura cerebri, but no further. We are thus ignorant of the upper limit of the change, and it is quite possible that it sometimes extends up to the cortex.

In the anterior horns it is chiefly the most anterior ganglion-cells which perish (Fig 265 *a*), those of the intermedio-lateral tract are scarcely if at all affected, while those of Clarke's columns are quite exempt

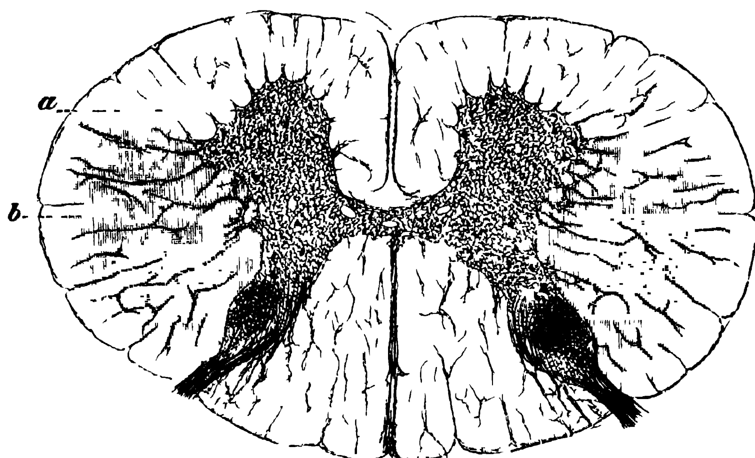


FIG 265 AMYOTROPHIC LATERAL SCLEROSIS

(*Section through the cervical cord* × 10)

a anterior horns, the ganglion cells of which have almost all disappeared
b diseased region of the lateral column corresponding to the completely decussated pyramidal tract

Of the motor nuclei of the cerebral axis those of the hypoglossal, facial, and spinal accessory nerves are the most liable to atrophic change, and to a very much less extent those of the abducens and trigeminal nerves Details regarding the limits to which the atrophy may extend are unfortunately lacking.

In proportion to the atrophy of the motor ganglion-cells in the cord and medulla we have of course progressive atrophy of the corresponding motor nerves and muscles

Amyotrophic lateral sclerosis is from a pathological point of view closely akin to anterior poliomyelitis, or spinal paralysis with wasting of the ganglion-cells in the anterior horns (Arts 640, 659)

CHARCOT, ERB (*Virch. Arch.* vol. 70), and others incline to the belief that a primary form of sclerosis of the pyramidal tracts exists, unaccompanied by degeneration of the anterior horns, and giving rise to a group of symptoms described by ERB as spastic spinal paralysis, by BERGER as **primary lateral sclerosis**, and by CHARCOT as spasmodic tabes dorsalis. STOFFELA (*Wien. med. Woch.* 21, 1878) describes a case of sclerosis of the lateral columns only, but the anatomical examination was not sufficiently minute to prove that it was a primary lateral sclerosis. The like is true of the older instance given by TÜRCK (*Wiener Sitzungsber.* XXI 1856). Probably it was a case of amyotrophic lateral sclerosis. See however DRESCHFELD, *Journ. of Anat. and Physiol.* XV. 1881, and the cases and references given by ROSS, *Diseases of the nervous system* II London 1883. The author's experience induces him to agree with LEYDEN (*Berl. klin. Woch.* 48, 1878), SCHULZ (*D. Arch. f. klin. Med.* XXIII), WEISS (*Wien. med. Woch.* 1883), and STRÜMPELL (*Arch. f. Psych.* X), in their view that the symptoms of spastic spinal paralysis may be caused by disseminated sclerosis, myelitis, degeneration from compression, tumours, spinal meningitis, hydromyelia, etc. The nature of the lateral sclerosis of chronic insane paralytic patients (WESTPHAL, *Virch. Arch.* vol. 40; SCHULTZE, *Arch. f. Psych.* IX) is still in dispute: FLECHSIG regards it as a secondary degeneration, WESTPHAL as a primary affection.

References on the morbid anatomy of tabes dorsalis:—LEYDEN, *Die graue Degen. d. hint. Rückenmarksstränge* Berlin 1863, *Klinik d. Rückenmarkskr.* II, *D. Zeitschr. f. klin. Med.* 1877, Art. *Tabes dorsalis* in *Realencyclop. d. gesammt. Heilkunde*; PIERRET, *Arch. de physiol.* III (1870), IV, V, *Les symptomes céphaliques du tabes dorsalis* Paris 1876, *Gaz. méd. de Paris* 1882; FROMMANN, *Unters. üb. norm. u. path. Anat. d. Rückenmarks* Jena 1867; RINDFLEISCH, *Path. Histology* II London 1873; SOLLY and CLARKE, *St Thos. Hosp. Reports* 1870; WESTPHAL, *Arch. f. Psych.* V, IX, XII, XVI; WOLFF, *ibid.* XII; ADAMKIEWICZ, *ibid.* IX, X, XII, *Trans. internat. med. congress* II London 1881, *Die Rückenmarksschwindsucht* Vienna 1885; TAKACS, *Cent. f. med. Wiss.* 1878, *Arch. f. Psych.* IX; CHARCOT, *Diseases of the nervous system* London 1876—80; VULPIAN, *Maladies du système nerveux* Paris 1879; SIMS WOODHEAD, *Journ. of Anat. and Physiol.* XIV (1882); ERB, *Ziemssen's Cyclopaedia* XIII; FRIEDREICH, *Virch. Arch.* vols. 26, 27, 68, 70; STRUMPELL, *Naturforscherversammlung in Salzburg* 1881, *Arch. f. Psych.* XII (1882) (and *Brain* V 1882); JÄDERHOLM, *Nord. med. Arkiv* I; KAHLER, *Zeitschr. f. Heilk.* II (1882); RAYMOND and ARTAUD, *Soc. de biol.* July 1882; ROSS, *Diseases of the nervous system* II London 1883 (with numerous references); BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884 (for good figures); BUZZARD, *Brain* VI 1884 (disease of blood-vessels); KRAUS, *Neurolog. Centralb.* 1885; DÉJÉRINE, *Arch. de physiol.* 1884; BABINSKI, *ibid.* 1885; LISSAUER, *Fortschritte d. Med.* III 1885.

References on amyotrophic lateral sclerosis and bulbar paralysis:—DUCHENNE, *Gaz. hebdom.* 1859, 1861; CHARCOT, *Diseases of the nervous system* II London 1880; FLECHSIG, *Ueber Systemerkrankungen* Leipzig 1878; BARTH, *Arch. d. Heilk.* XII, XV; DUMÉNIL, *Gaz. hebdom.* 1867; LEYDEN, *op. cit.*, *Arch. f. Psych.* II, III, VIII; MAIER and KUSSMAUL, *Virch. Arch.* vol. 61; GOMBAULT, *Arch. de physiol.* IV; PICK, *Arch. f. Psych.* VIII; PITRES, *Arch. de physiol.* 1876; LÉPINE, *Gaz. méd. de Paris* 17, 1878; WESTPHAL, *Virch. Arch.* vol. 40; KUSSMAUL, *Sammlung klin. Vorträge* 54; WORMS, *Arch. de physiol.* IV (1877); CORNIL and LÉPINE, *Gaz. méd. de Paris* 1875; FERRIER, *Lancet* 1, 1881; STADELMANN, *D. Arch. f. klin. Med.* XXXIII; MOELI, *Arch. f. Psych.* X; VIERORDT, *ibid.* XIV; DÉJÉRINE, *Arch. de physiol.* VI (1883); MINKOWSKI, *D. Arch. f. klin. Med.* XXIV (1884); ORMEROD, *Brain* VIII 1886 (a critical digest).

On sclerosis affecting more than one tract ('combined degeneration'):—WESTPHAL, *Virch. Arch.* vols. 39, 40, *Arch. f. Psych.* V, VIII, IX, XV (causation of spastic spinal paralysis); KAHLER and PICK, *ibid.* VIII, X; SCHULTZE, *Virch. Arch.* vol. 79, *Arch. f. Psych.* V; FRIEDREICH, *Virch. Arch.* vols. 26, 27, 68, 70; STRÜMPELL, *Arch. f. Psych.* XI; PRÉVOST, *Arch. de physiol.* IV

(1877); WOLFF, *Arch. f. Psych.* XII; HAMILTON, *New York med. record* XV (1879); BABESIU, *Virch. Arch.* vol. 76; ORMEROD, *Brain* VII 1885 (a critical digest of the literature).

648. From what we have said in the last Article it will be seen that both in tabes dorsalis and in amyotrophic lateral sclerosis the morbid change follows the course of certain definite tracts, and the question at once arises whether in these cases we have what with FLECHSIG we may call **primary systemic diseases**. If by a 'system' we mean one definite group of homologous nerve-fibres and their ganglion-cells, and this only, these affections can hardly be described as simply 'systemic,' inasmuch as at least in tabes various systems are involved. Tabes would in that case be properly described as a combined systemic disease (STRÜMPELL). But if we include under the term 'system' a group of fibres and cells all *functionally* related, both tabes and amyotrophic lateral sclerosis are systemic.

The **morbid change in tabes** has been very variously interpreted by different authors. LEYDEN regards it as a degenerative process, CYON, FRIEDREICH, and FROMMANN regard it as inflammatory, CHARCOT calls it a parenchymatous inflammation, ERB a chronic myelitis, ADAMKIEWICZ thinks the essential fact is a chronic degeneration of the connective tissue.

Minute microscopic examination shows however that the process is essentially a degenerative one, having nothing to do with inflammation; and STRUMPELL accurately expresses the facts when he describes it as a degeneration of functionally related nerve-fibres.

According to PIERRET, CHARCOT, and STRUMPELL the disease begins with the degeneration of certain strands of fibres running through the middle of Burdach's columns (Fig. 266 *a*), and usually in the lumbar and dorsal regions of the cord. At the same time degenerate fibres appear in the posterior nerve-roots, and along the inner (or median) aspect of Goll's columns in the dorsal and cervical regions there is a sclerotic strip. After a time Burdach's columns in the cervical region are likewise invaded.

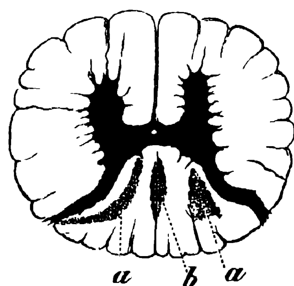


FIG. 266. COMMENCING SCLEROSIS OF THE POSTERIOR COLUMNS.

(*After* CHARCOT: *section from the dorsal region:* × 5)

a sclerotic patch in the cuneate fasciculus
b sclerotic patch in the columns of Goll

We have thus at first patches and strips of degeneration occurring in centripetal fibres which enter the cord through the posterior roots. This is followed by secondary ascending degeneration of the fibres initially attacked in the lower part of their course. Tabes according to this view then is a localised multiple ascending degeneration prima-

rily affecting a part of the region of the posterior columns, which with its associated secondary degenerations extends in the course of years over nearly the whole of that region.

As to the **cause** of the first onset of the affection—whether it depends on some congenital or acquired weakness of the centripetal tracts, or on disordered nutrition from disturbance of the circulation—it is not easy to decide. The fact that some forms of tabes appear to be inherited or at least congenital (FRIEDREICH) supports the former supposition, while the latter agrees with the observation that very frequently we find almost from the commencement of the disease like disorder of the optic, oculomotor, and trigeminal nerves, while simultaneously with its progress multiple patches of sclerosis appear in other parts of the brain and cord. When simultaneous degeneration of other systems of fibres takes place we can only suppose that the like weakness of organisation or disorder of nutrition is affecting them also. At least there is no ground for the theory that the imagined inflammatory process has extended by continuity from the primarily diseased posterior columns to other tracts.

At present we cannot say anything as to the real nature of the exciting cause. Clinical observers mention a great variety of predisposing conditions, such as cold, over-exertion, sexual excess, etc. FOURNIER, ERB, GOWERS, and others have lately laid special stress on **syphilis** as the commonest of all antecedents of tabes. If when the pathogenic agency is extrinsic the sensory tracts alone are affected, we must assume either that they have been congenitally weaker than the others, or that they are normally less able to resist certain forms of injury.

The like difficulties arise in the case of amyotrophic lateral sclerosis. Here also we are driven to conclude that the disease is a result of a localised degeneration occurring primarily in the region of the motor tract, perhaps also in the motor nuclei, and followed by a secondary degeneration along the course of the pyramidal fibres. This is the more likely inasmuch as the degeneration of the pyramidal tracts is most marked and typical when the degeneration affects chiefly the medulla oblongata; while a like degeneration beginning in the grey matter of the lumbar cord is not as a rule followed by any appreciable change in the pyramidal tracts (Art. 640). In some cases indeed (ZIEGLER) the medulla shows not only atrophy of the ganglion-cells of the grey nuclei but also patches of softening in the white matter of the pyramids: descending secondary degeneration may well start from the latter also.

When portions of the white matter of the anterior root-zones and neighbouring lateral regions are affected as well as the pyramidal tracts, we may explain the apparent complication by assuming that fibres belonging to the anterior (uncrossed) pyramidal tracts run through the anterior root-zones (FLECHSIG), as

they sometimes do; while we also bear in mind that the atrophy of the ganglion-cells of the anterior horns involves atrophy of the root-fibres entering and leaving the white substance. Perhaps in some cases fresh primary foci of degeneration appear in the region of the commissural fibres of the anterior columns. And when as has been observed in a few instances the posterior columns are likewise affected, we must infer that there too some isolated patch of degeneration has led to secondary degeneration of the tract.

Many authors (FRIEDREICH, SCHULTZE, KAHLER, PICK) have asserted that defective development of the conducting columns is frequently the principal cause of primary systemic degeneration. In support of this they point to the fact that certain forms are hereditary (FRIEDREICH, *Virch. Arch.* vols. 68, 70; RUTIMEYER, *ibid.* vol. 91; DRESCHFELD, *Liverpool and Manchester med. and surg. reports* IV 1876; ORMEROD, *Brain* VII 1884; EVERETT SMITH, *Boston med. and surg. journ.* 1885; BURY, *Brain* VIII 1886, with summary of cases), and that in these cases post-mortem examination has revealed changes explicable only on the supposition of imperfect development of the cord. It cannot be denied that in some cases hereditary conditions play a considerable part. In others, and these the majority, there is no evidence of such conditions, and we must look elsewhere for the causes of the disease. ERB (*D. Arch. f. klin. med.* XXIV (1879), *Cent. f. med. Wiss.* 1881, *Trans. internat. med. congress* II 1881, *Berl. klin. Woch.* 32, 1883), FOURNIER (*L'ataxie locomotrice d'origine syphilitique* Paris 1882), GOWERS (*Lancet* 1, 1881), ALTHAUS (*Trans. internat. med. congress* II 1881), VOIGT and RUMPF (*Berl. klin. Woch.* 1883), EULENBURG (*Virch. Arch.* vol. 99), and others have pointed out the great significance of syphilis in this connexion, some going so far as to say that 80 to 90 per cent. of tabic patients have suffered from syphilis. Even though other observers like WESTPHAL and BUZZARD have been unable to agree with such high estimates it appears plain that the influence of syphilis in the genesis of the disease is an important one.

ADAMKIEWICZ has carefully investigated the distribution of the blood-vessels in the cord (*Wiener Sitzungsber.* LXXXIV, LXXXV 1882, XC 1884) and shows that the degeneration of the posterior columns is coextensive with the vascular territory of the arteries which enter from the posterior circumference and the posterior longitudinal fissure. Even if we cannot suppose that all the vessels entering from these situations become successively diseased, we may at least imagine that the initial or primary lesion is due to disease within the territory of some of them, and that this lesion is the starting-point of secondary degeneration of the corresponding tracts. This at least would explain why the process sometimes does not extend over the whole of the posterior columns and the adjacent grey matter. On the other hand the fact that the disease of the posterior columns so often coexists with like disease of other systems and tracts shows that the degeneration may start in other vascular territories also.

TUCZEK (*Arch. f. Psych.* XIII) states that in ergotism changes resembling those in tabes appear in the posterior columns: according to LEYDEN this is also the case in pellagra (Art. 367). BRUNELLI (*Trans. internat. med. congress* II 1881) attributes an affection presenting the symptoms of lateral sclerosis to the use of bread contaminated with *Lathyrus cicera.* If these observations are confirmed in numerous cases they will go to show that certain poisons have a selective action on definite tracts of the central nervous system (ADRIANI, *La pellagra* Perugia 1880; ALTHAUS, *Brit. Med. Journ.* 1, 1884).

The fact that we occasionally meet with thickening of the meninges in tabes does not prove that the disease originally starts in meningitis. The thickening of the pia mater may quite well be a secondary process, though of

course it is possible that it may be primary and give rise to the characteristic degenerative changes in the cord.

WESTPHAL (*Virch. Arch.* vols. 39, 40, and *Arch. f. Psych.* XII 1882) and CLAUS (*Allg. Zeitschr. f. Psych.* XXXVIII 1881) have shown that in patients suffering from paralytic dementia (general paralysis of the insane) grey degeneration or sclerosis of the posterior columns is very common. The inference is either that such patients are peculiarly liable to tabes, or that the exciting causes, which in the brain produce the changes that are manifested as progressive paralysis, are potent to give rise in the cord to grey degeneration. See STEWART, *Glasgow Med. Journ.* 1886.

DÉJÉRINE (*Soc. de biologie* Feb. 18, 1882, *Arch. de physiol.* 1883, *Comptes rendus* 1883) states, what had already been pointed out by FRIEDREICH and WESTPHAL, that in tabes the peripheral nerves undergo degeneration. He infers that the affection is primarily a peripheral one; but the facts afford no real ground for such a supposition. See also SAKAKY, *Arch. f. Psych.* XV; OPPENHEIM and SIMMERLING, *Neurol. Centralb.* 11, 1886.

649. **Multiple sclerosis.** This is a peculiar affection of the brain and cord characterised by the formation of a number of grey condensed patches in the nervous tissues. It is either confined to the cord or extends over the whole of the central nervous system.

The patches are some of them superficial, some deep: in the former case they can be recognised by their grey colour. Sometimes they are rounded in shape, sometimes elongated and irregular. Their diameter varies from 1 millimetre to 50 or more. On section they look uniformly grey and translucent, occasionally one or two are mottled with white and softer than the others. They are usually sharply-defined against the sound tissue, though now and then a patch is surrounded by an ill-defined zone of a greyish-white or mottled appearance. In general they are firm and dry, but cases occur in which they are softer than the healthy tissue and contain a quantity of liquid that escapes on section.

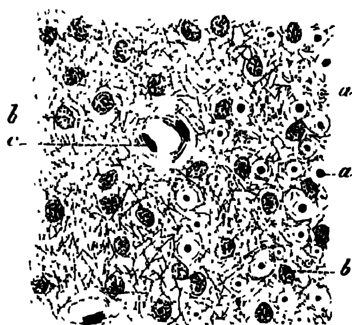


FIG. 267. SCLEROTIC PATCH IN THE WHITE MATTER OF THE CORD.
(*Section treated with Müller's fluid, alcohol, and carmine:* × 300)
a section of nerve-fibres
b neuroglia-cells
c blood-vessels

The dense patches (Fig. 267) consist of a close feltwork of delicate sharply-contoured fibres, beset with a larger or smaller number of nuclei. Within the larger and firmer patches no nerve-fibres can be seen; in the smaller and more recent or round the border of the larger ones a few still persist (*a*): they are usually normal in appearance, though sometimes they show signs of degeneration. Fat-granule cells are in some cases entirely absent, though in general a few can be seen.

The vessels (*c*) are at times unaltered, in other cases their walls undergo a hyaline thickening

or the adventitial coat is denser than usual. Sometimes too the adventitial lymph-sheaths contain lymphoid and granule-carrying cells, while leucocytes in varying number are scattered through the surrounding nerve-tissue.

Most of the nuclei that are visible belong however to the neuroglia-cells, which have a scanty protoplasm and a large number of glistening processes (Art. 638, Fig. 253). The feltwork is in fact essentially composed of the interlacing processes of these cells.

A few corpora amylacea occur here and there.

The softer and more gelatinous patches have a looser feltwork, with wider meshes and interstices. Those that are mottled with white contain numerous granule-cells and other products of nerve-disintegration. If they lie within the grey matter they sometimes contain also atrophied and shrunken or hyaline and swollen ganglion-cells.

The affection is commonest in the cord, and varies very greatly in its extent. There is nothing special about the manner in which the patches are distributed: they may lie anywhere in the grey matter as well as in the white (Figs. 268, 269, 270). When they interrupt conducting tracts, more or less extensive secondary degeneration of these ensues, but it is surprising to note how frequently the latter change is absent even when the sclerotic patches are pretty large. If the sclerosis should cause the destruction of ganglion-cells in the anterior horns some of the anterior root-fibres of course become atrophied.

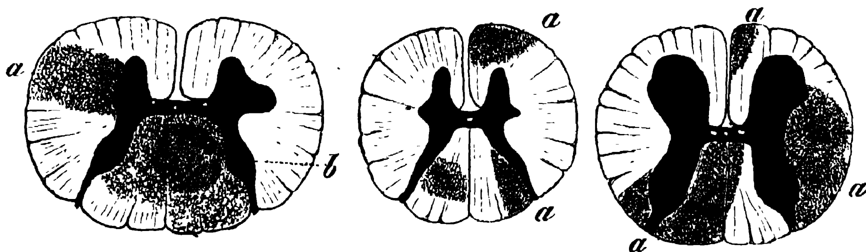


FIG. 268. FIG. 269. FIG. 270.

DIAGRAMS OF MULTIPLE SCLEROSIS (× 3).

FIG. 268. CERVICAL REGION.
a sclerotic patch in the lateral column and left intermedio-lateral tract
b patch in the posterior columns

FIG. 269. DORSAL REGION.
a disseminated patches

FIG. 270. LUMBAR REGION.
a disseminated patches

In the brain the chief seats of multiple sclerosis are the white matter near the lateral ventricles, the corpus callosum, the corpora

striata, the pons, the crura cerebri, and the dentate nucleus. Often too the optic, olfactory, and trigeminal nerves, and the roots of the spinal nerves, are found diseased. In the case of the brain we now and then find that a large portion of the roof of the lateral ventricle is transformed into grey sclerotic tissue several millimetres thick. Multiple sclerosis of the cortex is comparatively rare.

650. In most cases when the grey patches of multiple sclerosis come under observation the tissue-change is well advanced, and appears to be due to increase of the neuroglia and consequent compression and atrophy of the nerve-elements. This late appearance gives us however no certain knowledge as to the origin and course of the affection. Even when the increase by hyperplasia of the connective tissue is the most obvious feature in the ultimate result, it does not follow that the change began with such hyperplasia.

In fact there is no doubt that in many cases the disease begins as a degeneration, dependent primarily on a disturbance of nutrition, and first affecting the nerve-elements. Cases sometimes occur in which the typical grey sclerotic patches are accompanied in the brain and cord by others which are mottled with white, or uniformly white and opaque, or even pale-yellow; and these manifest on the one hand all grades of degenerative change, on the other an obvious proliferation and hyperplasia of the neuroglia (Art. 638, Fig. 253). In teased preparations we find not only abundance of nerve-detritus and granule-cells, but also numerous neuroglia-cells whose protoplasm is abundant and nuclei multiplied: and as we have seen (Arts. 638, 639) there is no doubt that degenerative changes in the nerve-elements may be followed by multiplication of neuroglia-cells and formation of sclerotic patches.

The changes we are considering are certainly often of a non-inflammatory kind, being simply the results of disordered nutrition due to change or impurity in the blood, to thickening or degeneration of the vessel-walls, or to disturbance of the circulation. It is at any rate remarkable how frequently we find morbid changes in the vessel-walls in connexion with sclerotic patches. Once however a sclerotic hyperplasia has begun it may extend to contiguous parts without any antecedent degeneration.

Though we are thus able in a number of cases to refer the sclerotic process to a primary degeneration, it does not follow that this is the invariable rule. Both in the brain and in the cord inflammatory processes may be set up which after they have caused the destruction of a certain amount of nerve-substance come to an end by what we might call sclerotic cicatrisation.

When a patch of inflammatory degeneration is formed and the acute changes have ceased, absorption of the detritus and exudation takes place exactly as in the case of ischaemic degeneration or

softening. If the destruction is extensive a permanent defect or hiatus will remain: if it is more limited after the disintegration and absorption of the nerve-elements there is left a tissue consisting of neuroglia (Fig. 271 *B*) and a network of vessels (*d*). This is partly old and persisting tissue, partly new-formed; its essential components are stellate or multipolar cells (*b*) whose processes freely anastomose. After absorption is complete a clear liquid containing a few leucocytes (*c*) lies in the meshes of the tissue. The result is a grey moist gelatinous patch, an example of what is called **grey gelatinous degeneration.**

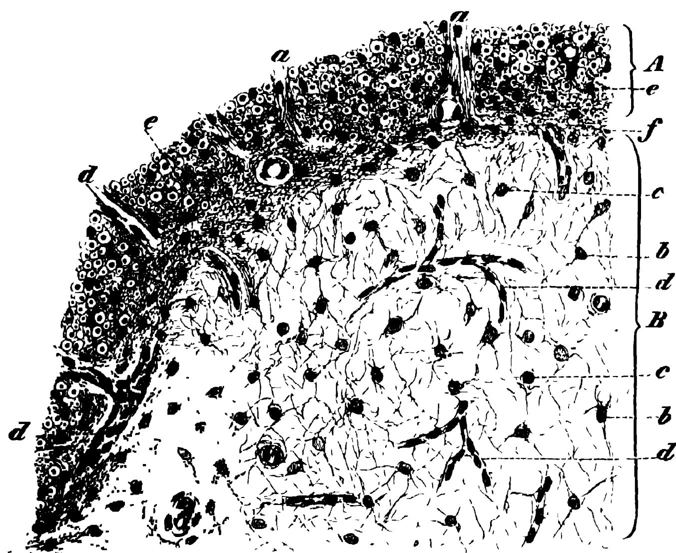


FIG. 271. GREY GELATINOUS DEGENERATION OF THE ANTERIOR HORN.

(*From the lumbar cord,* 18 *months after an attack of acute poliomyelitis: prepared with Müller's fluid, haematoxylin and carmine, and Canada balsam:* × 200)

A white matter
a atrophied anterior roots
b branching neuroglia-cells forming a network of fine glistening fibres
c round cells without processes
d blood-vessel

B apex of the anterior horn
e sclerosis of white matter contiguous to
f dense sclerosis of the margin of the anterior horn

Such gelatinous patches are usually surrounded by a zone in which the network of neurogliar fibres is much denser (*ef*), and might almost be called a feltwork, and the nerve-elements of the contiguous tissue are as it were embedded in the dense overgrowth which surrounds them (*e*). This change which in gelatinous patches is only marginal becomes in other cases general. Dense hyperplasia of the neuroglia may take place throughout the whole extent of a degenerating patch, and give rise to what is called hard sclerosis, or simply sclerosis (taken in a restricted sense).

Sclerotic patches such as we have described occur chiefly as

the result of isolated local inflammations in the cord (Art. 659). Whether the disease known as multiple sclerosis is frequently or indeed at all a result of multiple inflammations is a question still unsettled. The occurrence of a disseminated miliary encephalitis and myelitis is in favour of an affirmative answer.

Although we are thus able in many cases to refer the causation of multiple sclerosis to primary degenerative or inflammatory processes, other cases are met with in which there are no grounds for such an assumption. These are cases both of ordinary multiple sclerosis and of the form which is described as **granular ependymal sclerosis.** The latter is a morbid change of the lining membrane of the cerebral ventricles characterised by the formation of small prominent grey granulations on its surface. In extreme cases these beset the ependyma so closely that it feels rough to the touch. Sometimes the little prominences coalesce and form reticulate or arabesque patterns on the surface.

Histologically the change consists in a new-formation of neuroglia, the fibrous feltwork being exceptionally dense in proportion to the number of cells or nuclei present. The cylindrical epithelium which invests the ventricle sometimes continues to cover the prominences, sometimes falls away and leaves them bare.

Diffuse forms of ependymal and subependymal sclerosis are also met with. If the process extends from the floor of the fourth ventricle to the deeper structures it may cause the destruction of the ganglion-cells in the grey nuclei of the cranial nerves.

We do not yet know the nature of the exciting cause of these affections: the fact that they are frequently associated with chronic meningitis would suggest that they are of a chronic inflammatory character. In some cases circumvascular collections of cells are found in the subependymal tissue, and in this respect the granulations recall the structure of inflammatory papillomata of the skin (Art. 394).

Not infrequently extensive proliferations take place in the connective tissue about the central canal of the cord; they occur both in patches and as continuous longitudinal growths (Art. 637). As they are met with chiefly in connexion with malformations of the canal, or in regions which experience shows to be liable to congenital anomaly, *i.e.* about the posterior columns, it seems fair to suppose that they depend on some congenital anomaly of structure in the tissues. Moreover, these proliferations are sometimes accompanied by sclerotic patches in other parts of the central nervous system, and hence it is not improbable that other multiple scleroses may occasionally be referable to disorders of development.

Many writers speak of all grey degenerations, hard or gelatinous, as scleroses. The etymology of the term (σκληρος hard and dry) would limit its application to the former variety. If however we extend the word to cover

both varieties, and indeed they are genetically equivalent, we should perhaps speak of them as hard sclerosis and gelatinous sclerosis respectively.

The genesis of multiple sclerosis (called variously disseminated, insular, focal, or cerebrospinal sclerosis) is still very differently explained by different writers. Some regard the degeneration of the nerve-elements as the primary lesion, others the hyperplasia of the neuroglia: others again describe the process as a chronic inflammation, or affirm that the overgrowth of fibrous tissue starts from the vessel-walls. In the author's own investigations, undertaken specially to determine these questions, he found that in recent cases the degenerative changes were so marked as to admit of no other supposition than that they were primary, and the multiplication of neuroglia-cells secondary. Cases do occur however where no patches of sclerosis can be found in which this pre-eminence of the degenerative changes is clearly apparent: and it is therefore not easy to disprove the statements of CHARCOT and others who regard the overgrowth of fibrous tissue as the primary cause (by compression) of the degeneration of the nerve-elements. Various facts go to show that forms of cerebrospinal sclerosis occur which are the result of anomalies or disorders of development, and are thus related to the peri-ependymal growths met with in syringomyelia. It is also possible that other forms are due to the formation of multiple foci of inflammation.

References on multiple sclerosis:—LEYDEN, *Deutsche Klinik* XV 1863 and *Klinik d. Ruckenmarkskr.*; RINDFLEISCH, *Virch. Arch.* vol. 26; ZENKER, *Zeitschr. f. rat. Med.* XXIV (1865), *D. Arch. f. klin. Med.* VIII (1870); CHARCOT, *Diseases of the nervous system* I London 1876; BOURNEVILLE, *La sclérose en plaques disséminées* Paris 1869; SCHULE, *D. Arch. f. klin. Med.* VIII; BUCHWALD, *ibid.* X; OTTO, *ibid.* X; JOLLY, *Arch. f. Psych.* III; ARNDT, *Virch. Arch.* vols. 64, 68; MOXON, *Guy's Hosp. Reports* XX (1875); DICKINSON, CHEADLE, DRESCHFELD, *Med. Times and Gaz.* 1, 1878; LEYDEN, *Charité-Annalen* III, *Arch. f. Psych.* VI (sclerosis of bulbar nuclei), *Berl. klin. Woch.* 1878; SCHULTZE and RUMPF, *Cent. f. med. Wiss.* 1878; ERB, *Ziemssen's Cyclopaedia* XIII; FROMMANN, *Virch. Arch.* vol. 54, *Normale und path. Anat. d. Nervensystems* Jena 1876, *Die Gewebsveränd. bei mult. Sclerose* Jena 1879; RIBBERT, *Virch. Arch.* vol. 90; FRIEDMANN, *Jahrb. f. Psych.* IV (1883); BRAMWELL, *Diseases of the spinal cord* Edinburgh 1884 (for good figures); GOWERS, *Lancet* 1, 1886 (miliary sclerosis of brain).

On ependymal sclerosis and spinal periependymal sclerosis:—ROKITANSKY, *Handb. d. path. Anat.* I (trans. Syd. Soc. London 1850); VIRCHOW, *Gesamm. Abhandlungen* Frankfort 1856; WEISS, *Oesterreich. med. Jahrb.* 1878; MAGNAN and MIERZEJEWSKY, *Arch. de physiol.* 1873; LEYDEN, *Klinik d. Ruckenmarkskr.* II; SCHULTZE, *Virch. Arch.* vols. 70, 87; FRIEDREICH, *ibid.* vol. 26; KAHLER and PICK, *Arch. f. Psych.* VIII; EICKHOLT, *ibid.* X; WESTPHAL, *Brain* VI (1883), *Arch. f. Psych.* XVI (1885); see also Art. 637.

On multiple and diffuse sclerosis in infants and children:—VON RECKLINGHAUSEN, *Verh. d. geburtshilfl. Gesellsch. zu Berlin* 1863; NEUREUTTER and STEINER, *Prager Vierteljahrsschr. f. pract. Heilk.* XX (2); HUMPHREYS, *Med. Times and Gaz.* 2, 1877; POLLARD, *Lancet* 2, 1878; HARTDEGEN, *Arch. f. Psych.* XI; POLLACK, *ibid.* XII.

651.* When from simple or degenerative atrophy or inflammatory disturbance of nutrition the nerve-elements belonging to a considerable extent of tissue have perished, a diffuse hyperplasia of the connective tissue often sets in, and in advanced cases gives rise to a continuous induration, or **diffuse sclerosis** as it is called. This change occurs for instance in simple atrophy of the cerebellar cortex (Art. 640). It is also common in atrophy of the marginal portions of the cord and in atrophy of the cerebral cortex, such as follows grave local disorder of nutrition from chronic inflammation

of the pia mater. In the cord we may have a marginal sclerosis of this kind (Fig. 272), exactly resembling in its structure the scleroses we have already described. In the cortex of the cerebrum the induration is seldom great, and it is only on microscopical examination that the stellate neuroglia-cells and their fibrous processes are seen to be more abundant and more obvious than in the normal tissue (Art. 656, Fig. 273). Only when the antecedent atrophy has been very extensive is the hardening of the surface so palpable as to be recognisable by the finger.

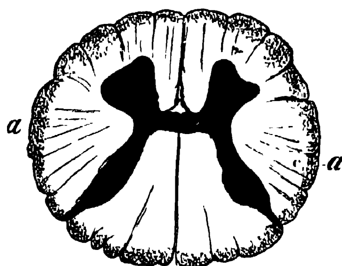


FIG. 272. MARGINAL SCLEROSIS OF THE CERVICAL CORD.
(*Diagrammatic:* × 3)
a sclerotic marginal zone

This induration is secondary, but there is also a form of primary hyperplasia of the neuroglia which sometimes extends over considerable portions of the central nervous system. In the general enlargement of the brain known as cerebral hypertrophy (Art. 633) the connective tissue is said to undergo a notable increase, giving the tissue a leathery or rubber-like consistency. This increase is more obvious in some peculiar indurative conditions of particular portions of the brain, in which the normal form and aspect remain unchanged while the size is more or less enlarged. A convolution, a lobe, the corpus callosum, or the basal ganglia may thus become indurated *en masse;* or in the white matter ill-defined portions of tissue may be palpably harder than the parts around without any discoloration or other apparent change. Such indurations are all due to increase of the connective tissue: in some of them the brain-substance is transformed into a felted mass of delicate fibres containing a few scattered nerve-cells and nerve-fibres or in some parts none at all.

Diffuse scleroses cannot be sharply distinguished from the new-growths known as gliomata (Art. 662), and must be considered with them. We know nothing as to the causes of the change, though it is at least possible that they are dependent on some disturbance of the histological development of the tissues in which they occur.

References on diffuse sclerosis:—STRÜMPELL, *Arch. f. Psych.* IX; SIEMENS, *ibid.* X; F. SCHULTZE, *ibid.* XI; ZACHER, *ibid.* XIII; GREIFF, *ibid.* XIV; ERLER, *Diffuse Hirnsclerose* In. Diss. Tübingen 1881; COTARD, *Hémiatrophie cérébrale* Thèse de Paris 1868; JENDRÀSS'K and MARIE, *Arch. de physiol.* V 1885.

CHAPTER XCV.

INFLAMMATORY DISORDERS.

Serous inflammations.

652. Acute inflammatory exudations having a serous character take place into the substance of the brain and cord, into the membranous envelopes, and into the ventricles; and they give rise to grave and even fatal disturbance of the nervous functions.

Acute serous leptomeningitis is an affection in which a sudden congestive hyperaemia is followed by serous effusion into the subarachnoid and pia mater, and into the cerebral ventricles. The quantity of liquid found in the membranes at the time of death varies somewhat in different cases, but it is seldom great. The amount of blood in the congested vessels is also by no means constant. The ventricles are more or less dilated by the effusion (inflammatory internal hydrocephalus); sometimes so greatly that the convolutions are visibly depressed and flattened by pressure against the skull, while the cerebrospinal liquid is to some extent forced out of the subarachnoid spaces. The choroid plexuses are usually hyperaemic: the liquid in the ventricles and subarachnoid spaces is clear or slightly opalescent, and often contains minute flakes of fibrin. It is richer in albumen than the normal cerebrospinal liquid (HUGUENIN) and has floating in it a few pus-corpuscles. A few extravasated leucocytes may be seen in the neighbourhood of some of the cortical vessels.

The disorder is commonest in infancy or early childhood, rare in adult life: it not infrequently accompanies the early stages of infective diseases such as measles or scarlatina. Very probably the oedema of the brain and meninges which sometimes supervenes in nephritis is in part at least of inflammatory origin. Perhaps too some of the cases in children are induced by the virus of epidemic cerebrospinal meningitis (Art. 653): frequently however no cause can be certainly assigned, though scrofula, rickets, and syphilis are believed to be predisposing conditions.

If the inflammatory oedema is not fatal it often disappears speedily, though sometimes it issues in a chronic inflammatory

condition manifested by thickening of the meninges and permanent and increasing dilatation of the ventricles: this condition is called **chronic hydrocephalus**, and it sometimes comes on gradually and insidiously, that is to say without any markedly acute onset.

Of more common occurrence than these genuine diffuse serous exudations is the **localised inflammatory oedema** of the brain, cord, or membranes which is set up around foci of purulent, granulating, septic, tuberculous, syphilitic, or traumatic inflammation, or around new growths.

When the nervous tissue is the chief seat of oedema it looks moist and glistening, and is softer than in health. There is usually some accompanying circumvascular extravasation of leucocytes, partly in the adventitial sheaths of the vessels, partly in the surrounding tissue.

Purulent inflammations.

653. **Purulent leptomeningitis.** Purulent inflammation of the soft membranes (pia mater and subarachnoid tissue) is preceded first by the hyperaemia which is the first stage of all acute inflammations, then by serous exudation, and lastly by an extremely abundant accumulation of leucocytes in the circumvascular spaces. The veins, engorged and dilated, show streaks and patches of yellow along their course, and these rapidly extend, owing to the continued extravasation and infiltration. The opacity thus occasioned sometimes becomes so dense that the gyri of the brain and the surface of the cord are entirely concealed by it.

In simply purulent meningitis the exudation is composed of pus-corpuscles and extravasated liquid. In the sero-purulent and fibrino-purulent forms the exudation has a turbid muddy appearance, is more liquid, and contains granules, fibres, and (less frequently) hyaline clots of fibrin.

The exudation lies mainly in the clefts and spaces of the pia mater and subarachnoid tissue. The cells covering the trabeculae of the connective tissue are for the most part cast off and degenerate. The veins and venules are thickly surrounded with leucocytes, and their walls penetrated by them. Sometimes the venous channel is crammed with leucocytes, especially towards its periphery; sometimes it is plugged with hyaline or granular coagula. When the arteries are surrounded by extravasated cells the adventitial coat is seen to be infiltrated with them, and the like is often true of the middle and inner coats.

The cortex of the brain and the cord are sometimes all but unaffected by the meningitis, being perhaps only slightly moister than usual, though it is frequently possible to demonstrate that changes have here and there taken place in the nerve-elements. In the cord we find swelling and partial disintegration of the axis-cylinders and degeneration in the medullary sheaths and nerve-

roots. In the cortex the ganglion-cells become swollen and lose their finer processes.

Often enough the inflammatory change advances along the vessels to the cortex, the pial sheaths especially of the veins becoming filled with leucocytes. Or the change may extend to the nervous tissues in a more generally diffused manner (Art. 654). The nerves issuing from the brain and cord are frequently infiltrated with cells.

When the inflammation extends through the transverse fissures of the base of the brain to the telae choroideae within the ventricles, a purulent or sero-purulent exudation is poured out, the liquid contents of the ventricles are augmented and rendered turbid, and the plexuses swell up and become covered over with pus or fibrino-purulent flakes. The ependyma and underlying brain-substance become moist and sometimes morbidly soft. When the distension of the ventricles is great the brain-substance is compressed, the gyri flattened, and the subarachnoid liquid forced out; the result being that the meningeal structures of the convexity become morbidly dry.

The seat and the extent of the inflammation vary greatly, depending of course on the exciting cause and on the manner in which it reaches the membranes. As to the nature and properties of the exciting causes we know little, but it is probable that micro-organisms are frequently at work, and probably also specifically distinct micro-organisms in different forms of the disease. In many cases micrococci have been found in the inflamed tissues, but it is not likely that they are always of the same kind or the same virulence.

Irritant matters (organic or not) may reach the meninges in the first place by way of the blood-vessels, in which case we might call the meningitis **embolic**.

If it chiefly attacks the convex surface it is described according to its distribution as local or general, unilateral or bilateral, meningitis of the convexity. Affecting the base it is called basal or basilar meningitis, and in the case of the cord spinal meningitis. In basal meningitis the cerebral axis is usually covered with pus, and the subarachnoid cisterns are much distended with the exudation.

Haematogenous purulent meningitis occurs in connexion with traumatic pyaemia, gangrenous and croupous pneumonia, ulcerative tuberculous phthisis, endocarditis, gangrenous bed-sores, acute rheumatism, purulent pleurisy (empyema), scarlatina, typhoid, inflammation of the umbilicus in infants, etc. It is moreover the essential symptom of the infective disease known as **epidemic cerebrospinal meningitis**. As its name indicates the exudation in this disease extends over cord and brain, though by no means uniformly. When the inflammation is at its height it is usually purulent or fibrino-purulent, seldom haemorrhagic, though cases rarely occur in which some small haemorrhages do not appear. If death

ensues within the first few days the quantity of exudation poured out is very small: sometimes nothing but a circumvascular infiltration of cells can be made out. In more advanced stages the subarachnoid liquid has a turbid whey-like appearance.

Both brain and cord are always involved, the cellular infiltration spreading from the pia mater along the vessels or directly to the cortex of the brain and the substance of the cord. In addition to this small patches of inflammation (sometimes haemorrhagic) are invariably found in the interior of the cerebrum: STRÜMPELL says they are usually very numerous. The smallest form mere clusters of cells in the pial sheaths of the vessels, the larger ones are quite extensive cellular infiltrations, and are accompanied by softening of the infiltrated region. If the patient survives these patches may become abscesses. Epidemic cerebrospinal meningitis is thus accompanied by encephalitis and myelitis, and even after cessation of and recovery from the meningeal affection **cerebral abscess** may be left as a sequela.

A second group of purulent inflammations are due to **extension** from contiguous parts, either by continuity or by way of the blood-vessels or lymphatics. Thus ostitis of a vertebra or of the petrous bone extends directly to the meninges; suppuration of the nose, frontal sinuses, base of the skull, scalp (ulcers, erysipelas, eczema), internal ear, and eye (panophthalmitis) lead to suppuration of the membranes, the various vessels which pass from the bone inwards to the membranes serving as channels of infection. Especially dangerous is puriform softening of thrombi within the veins of the skull or the sinuses of the dura mater. Lastly, purulent inflammation of the brain itself may lead to the like in the meninges. According to some (FISCHER, BILLROTH, HUGUENIN) simple concussion of the brain without any wound of the soft parts or bones occasionally gives rise to purulent meningitis; HUGUENIN and others say the same may occur after sun-stroke.

The inflammation in all these cases will naturally begin where the irritant or exciting cause first acts, that is to say, it begins as a local affection. The wide communication between the several subarachnoid spaces contributes however to the speedy extension and generalisation of the process.

Purulent meningitis, especially when it is cerebral, is usually fatal, though in some cases of the epidemic cerebrospinal disease recovery takes place. In the latter event the exudation is in the course of time re-absorbed, but usually certain whitish thickenings of the membranes due to fibrous hyperplasia, and some permanent dilatation of the ventricles, remain as evidence of the attack. Under certain conditions not fully understood the acute inflammation passes into a chronic one, the membranes undergoing cellular infiltration and becoming remarkably thickened. When the inflammation has been mainly confined to the pia mater, it may result in atrophy of the underlying nervous tissues (Art. 656).

STRÜMPELL and WEIGERT have suggested that in cerebrospinal meningitis the infective virus may perhaps pass from the nose into the interior of the skull. The author is unable to accept the suggestion. Though he is convinced that purulent meningitis does start from the nose, the phenomena of the epidemic affection appear to exclude that channel of infection. The manner in which the inflammatory change is distributed over the various parts of the meninges, the occurrence of numerous foci within the brain and cord, the frequent accompaniment of arthritis in various joints, etc. all indicate that the poison is spread by the channel of the blood-vessels, and thus reaches the central nervous system. The inflammation of the superior nasal meatus is a mere concomitant of the meningitis.

References on cerebrospinal meningitis:—ZIEMSSEN, *Ziemssen's Cyclopaedia* II; WUNDERLICH, *Arch. d. Heilk.* V, VII; ZENKER, *D. Arch. f. klin. Med.* I; STRÜMPELL, *ibid.* XXX; LANCEREAUX, *Traité d'anat. pathol.* II; RADCLIFFE, *Reynolds' Syst. of med.* II 1868; BURDON-SANDERSON, *Rep. of Med. Off. of Privy Council* 1866.

654. **Purulent encephalitis and myelitis.** In purulent meningitis the underlying nerve-tissue undergoes more or less extensive inflammatory change, and we might therefore very well describe the process as a meningoencephalitis or meningomyelitis. Under certain conditions however the inflammation of the brain or cord becomes the more marked feature, and this affects even the naked-eye appearance of the affected parts. This is especially the case in traumatic inflammations, set up by cuts, blows, stabs, or gun-shot wounds. The tearing and bruising of the tissue by the mechanical violence gives rise to disintegration or necrosis of the nerve-elements, while the weapon which causes the injury may penetrate the substance of the brain or cord, or drive before it splinters of bone, or lacerate the blood-vessels and lead to haemorrhage into the meninges or into the nerve-substance. If the wound becomes septic decomposition of the extravasated blood and of the damaged tissue takes place, and this induces violent purulent or putrid meningitis, encephalitis, or myelitis. The decomposing matters assume a dirty-brown, grey, or greenish colour and give off a putrid odour. The actual inflammation begins with swelling of the nerve-substance and the formation of numerous points of haemorrhage. The change first appears in the part near the injury, but often spreads widely, the haemorrhagic extravasation extending deeply into the tissue and also over a considerable area of the cortex beneath the inflamed pia mater. When the vessels are lacerated *ab initio* the swollen nerve-substance is tinged more or less deeply with yellow from the diffusion of the colouring-matter of the extravasated blood.

The haemorrhagic foci lie always in the immediate neighbourhood of small vessels, but as they grow larger they spread beyond the region of the adventitial lymph-sheaths into the nerve-tissue, and when the change is no longer quite recent they appear infiltrated with leucocytes which have left the vessels. This migration of leucocytes is the first stage of the suppurative process, and it steadily increases, until at length the nerve-tissue is as it

were inundated by the multitude of extravasated cells; and presently undergoes degeneration and dissolution. When a portion of the tissue is thus liquefied and converted into a yellowish or greyish or putrid pus-like cream, the encephalitis or myelitis has issued in **abscess.**

In like manner purulent meningeal inflammations due to other causes (*e.g.* suppuration of bone, or septic embolism) sometimes extend to the substance of the brain or cord and lead to abscess. As a rule however the process is not so violent or so rapid.

When irritant matters reach the interior of the brain or cord through the blood-vessels without affecting the meninges on the way, a local inflammation is set up which at first may not extend to the pia mater. If the irritant is one which has the power of setting up suppuration (such as the pyaemic micrococci), and lodges in a capillary or small vein, its first effect is to produce minute haemorrhagic extravasations. These in the course of a few days become yellowish-white, with perhaps some slight blood-staining in the larger patches, and rapidly assume the appearance of abscesses. The number of extravasated white cells increases steadily, and at length the nerve-tissue breaks down and liquefies.

If at the same time one or more of the arteries have been blocked by embolism the inflammatory changes are accompanied or preceded by those characteristic of anaemic or haemorrhagic necrosis (Art. 642). The final result is however the same: an abscess is formed, distinguished only from those already described by its possibly larger size.

Both forms of embolic suppuration occur under the same conditions as lead to purulent meningitis, namely pyaemia, endocarditis, suppuration or gangrene of the lung, putrid bronchitis, croupous pneumonia, cerebrospinal meningitis, etc.

Embolic abscesses arise most commonly in the cerebral hemispheres and cerebellum, rarely in the cerebral axis, and more rarely still in the cord: they are sometimes multiple. They contain as a rule creamy yellow or pale-greenish pus. The smallest are as large as a pin's head, the larger ones may occupy the greater part of a lobe: most frequently they are from the size of a walnut to that of a hen's egg.

When recent the wall of an abscess has a broken-down appearance, the tissue around being oedematous and often beset with small points of haemorrhage. If close beneath the pia mater an abscess generally sets up meningitis, and if it breaks into a ventricle a violent inflammation of that region ensues.

Only the very smallest abscesses are capable of absorption and repair by cicatrisation. The larger ones, if not fatal by pressure or meningitis, become enclosed in a granulating capsule or membrane and may exist for years in a quiescent state. So early as four weeks after its first appearance an abscess may be walled off from the surrounding tissue by a grey or greyish-red zone: in the

course of months the zone grows broader and firmer, measuring from 2 to 5 mm. across. This is simply granulation-tissue, which by and by is transformed into cicatricial fibrous tissue. In old abscesses the enclosing membrane is thus made up of an inner granulating layer of cells and vessels and an outer fibrous layer.

Once encapsuled or 'encysted' in this way, the abscess slowly grows by the accumulation of pus derived from the granulating membrane: this secretion is probably not continuous, and in long-standing abscesses must be very slight. The surrounding brain-tissue is compressed, and sometimes atrophies or even degenerates and breaks down. At any moment moreover inflammatory oedema and fresh cellular infiltration may be set up in the compressed tissue, and these give rise to disturbance of the cerebral functions and often enough lead to a fatal issue. Nor is the danger of perforation into a ventricle or extension to the pia mater by any means removed when the abscess is encapsuled. Cerebellar abscesses may by pressure on the veins of Galen set up dropsy of the ventricles. Recovery from a large abscess is indeed possible only after surgical evacuation of its contents.

References on cerebral abscess:—LEBERT, *Virch. Arch.* vol. 10; SCHOTT, *Wurzburg. med. Zeitschr.* II (1862); BILLROTH, *Arch. d. Heilk.* 1862; HUGUENIN, *Ziemssen's Cyclopaedia* XII; R. MEYER, *Zur Path. d. Hirnabscesse* In. Diss. Zürich 1867; MAAS, *Berl klin. Woch.* 1869; WYSS, *Jahrb. d. Kinderheilk.* IV (1871); CRUVEILHIER, *Anat. pathologique* part 33; NAUWERCK, *D. Arch. f. klin. Med.* XXIX; RETTELHEIM, *ibid.* XXXV 1885 (abscess after empyema); EISELSBERG, *ibid.* (abscess after sunstroke); TOYNBEE, *Diseases of the ear* London 1868; GULL, *Guy's Hosp. Reports* III (1857), *Reynolds' Syst. of med.* II London 1868; HAYEM, *Arch. de physiol.* 1868.

Chronic Meningitis.

655. **Secondary forms of chronic leptomeningitis.** Chronic inflammation of the cranial or vertebral bones, or of the dura mater, are apt sooner or later to extend to the arachnoid, the subarachnoid tissue, and the pia matter. This extension occurs most commonly in tuberculous and syphilitic disease, though it is also met with in other inflammations, such as for instance are set up by mechanical injury to the bones. The idiopathic inflammation known as internal pachymeningitis, which is characterised by the formation of false-membranes and adhesions on the inner surface of the dura mater, sometimes extends to the inner meninges also.

The arachnoid having no vessels of its own is only passively affected by the inflammatory process, and undergoes more or less extensive degenerative changes. In the pia mater on the other hand, and in the vascular portions of the subarachnoid meshwork, inflammatory disturbances of the circulation make their appearance, and lead in the first place to infiltration of the latter tissue and of the arachnoid.

The next stage varies with the character of the inflammation.

If it be of tuberculous or syphilitic origin, in course of time the arachnoid, the subarachnoid tissue, and the pia mater become milky and thickened, partly from cellular infiltration, partly from the new-formation of fibrous tissue. Adhesions are not infrequently formed between the dura mater and the arachnoid. These are usually most dense and abundant in traumatic pachymeningitis; in the idiopathic form they are soft, fibrinous, and vascular.

But secondary chronic inflammations of the inner meninges are still more frequently the result of acute or chronic disease of the brain and cord. Every subpial inflammatory and degenerative process affecting the nerve-substance is capable of inducing meningeal inflammation: and tumours of the brain or cord act in like manner either directly, or through destructive changes in their own substance or in the tissue about them.

The pia mater and the surface of the central nervous organs stand in the closest possible connexion, and in all degenerative processes affecting the latter, whether they are inflammatory or not, some of the products of disintegration are apt to reach the pial tissue and the subarachnoid spaces, and there give rise to turbidity or (in the case of haemorrhage) yellow or brown pigmentation. The turbidity is more marked when the disintegrated matters possess irritating properties and excite inflammation. Then abundant extravasation of leucocytes ensues, and in time a more or less extensive fibrous hyperplasia is the result. In many cases the hyperplasia is well marked (Art. 642, Fig. 260), the meninges becoming dense, thick, white, and opaque. Both the subarachnoid and the arachnoid tissue take part with the pia mater in this hyperplasia, the trabeculae of the former becoming thicker and coarser, new trabeculae being formed, and the characteristic structure of the tissues obscured or altered. Calcareous concretions are common in the thickened membranes; pale peculiar-looking cells are aggregated into spherical clusters, then become homogeneous, and lastly calcified, and are surrounded by tiny capsules of cells and new-formed fibrous tissue.

Secondary meningitis of the spinal cord is similar to that of the brain, and follows upon inflammations of the vertebrae or spinal dura mater. In some cases the inflammation also extends to the substance of the cord itself.

656. **Haematogenous chronic leptomeningitis.** We have already pointed out (Arts. 652, 653) that acute meningitis of haematogenous origin, if not fatal, may issue in recovery by re-absorption of the exudation; but this is frequently accompanied by some thickening of the membranes due to new-formation of fibrous tissue. In certain not fully understood conditions the acute disorder passes into a chronic form, characterised by persistent cellular infiltration, and consequent thickening and opacity of the meninges: chronic internal hydrocephalus is a further sequela.

But there are other forms of chronic leptomeningitis which as to their causation, rise, and progress, differ notably from the foregoing. We refer to those chronic (more rarely acute or subacute) inflammatory processes which are the most frequent though not invariable antecedent of certain mental disorders, especially that known as paralytic dementia or **progressive paralysis of the insane.** The processes in question and the mental disease as commonly defined are not exactly co-extensive: on the one hand they may be absent in cases where the mental disease exists, and on the other they are met with in cases where the symptoms if any have been other than mental.

The morbid conditions referred to have certainly not the same aetiological or clinical significance in all cases: they may be divided into two groups according to their anatomical characters, in other words according to their situation and the nature of the textural changes they induce.

In the first place we have changes affecting mainly the arachnoid and subarachnoid tissues and giving them a white opaque appearance, the opacity being limited to spots and streaks or more uniformly diffused: it is most apparent over the sulci and the subarachnoid cisterns, and occurs both at the base and on the convexity of the brain. It is still doubtful whether these opacities are always of inflammatory origin. They are histologically due to fibrous thickening, endothelial hyperplasia, or more rarely to cellular infiltration. If we are to reckon them provisionally as due to chronic inflammation, this would probably be best described as **chronic arachnitis** or **external leptomeningitis.** As to their causation they are observed in connexion with chronic venous engorgement and with certain morbid states of the blood, as in alcoholism and chronic nephritis.

Of greater importance than the changes just mentioned, which after all can hardly be supposed to induce grave disorder of the nervous functions, are certain chronic affections which involve chiefly the pia mater and underlying nerve-tissue: in their later stages at least they are unmistakeably inflammatory, and are therefore appropriately included under the terms **chronic meningoencephalitis** and **meningomyelitis.**

When the morbid process is well advanced the soft membranes, especially the pia mater, are visibly milky and opaque, the change showing best in the sulci along the blood-vessels, and sometimes also on the ridges of the convolutions. It is most common in the anterior parts of the brain, namely the frontal and parietal lobes, the other parts being little or not at all affected. Cases however are described in which the change is most marked in the temporal lobes.

The most striking of the textural changes is undoubtedly the cellular infiltration which pervades the pia mater (Fig. 273 *h*), and to a less degree the subarachnoid tissue (*b*). This is occasionally

accompanied by a more or less extensive fibrous hyperplasia of these structures. In later stages accumulations of leucocytes (i_1), and in smaller quantity red blood-cells and brown or yellow pigment (i_2), appear in the adventitial sheaths of the cortical vessels, and sometimes even of those supplying the white matter. But no great accumulations of cells are as a rule met with in the mass of the brain-substance itself. The cellular infiltration is not uniform, varying much even within the tissue of the pia

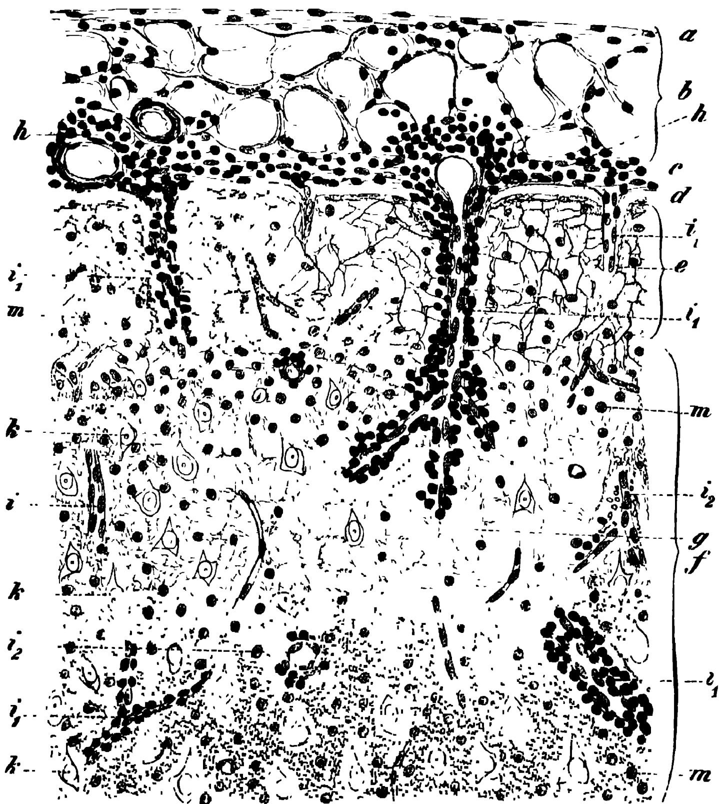


FIG. 273. CHRONIC MENINGOENCEPHALITIS WITH ATROPHY OF THE CORTEX.

(*Section hardened with Müller's fluid and alcohol, stained with alum-carmine and ammonia carminate, and mounted in Canada balsam:* ×150)

a arachnoid
b subarachnoid tissue
c pia mater
d superficial layer of cortex
e layer of small pyramidal cells; the cells have disappeared, and numerous stellate figures composed of glistening fibres have taken their place
f layer of large pyramidal cells,
g many of these have disappeared, a delicate reticulum remaining
h cellular infiltration of pia mater
i unaltered blood-vessel
i_1 pial sheath of vessel filled with leucocytes
i_2 pial sheath filled with blood-cells and pigment
k ganglion-cells (of the third layer)
m neuroglia-cells

mater. In the cortex comparatively few vessels are surrounded by masses of cells, and in the white matter perhaps one or two at most. Some of the vessels however show hyaline or fibrous thickening of the adventitial coat.

The nerve-substance of the cortex is probably never entirely normal in these cases; though it is not always easy to demonstrate the changes that exist. In very chronic cases it is often visibly atrophied, its depth being diminished to a half or a third of the normal: but the atrophy is far from being always uniform over the affected area, being sometimes most marked in particular convolutions or parts thereof. The atrophied areas are usually pale, seldom reddened, and are occasionally somewhat indurated.

As the white matter is at the same time diminished the affected portion of the brain is on the whole perceptibly smaller, and the space left vacant by the shrinking is filled up by liquid collecting in the subarachnoid tissue. Sometimes too the ventricles are dilated and their ependyma beset with granulations (Art. 650). When the atrophy is extreme the brain is sometimes so remarkably shrunken that it weighs less than 1000 grammes. The affection is therefore aptly described as **atrophic meningo-encephalitis.**

The outer layers of the grey matter are usually the most altered. In both pyramidal-cell layers (*e f*) the number of cells is diminished, and here and there are patches in which all of them have disappeared (*g*). In sections mounted in Canada balsam the loss of the nerve-elements causes the tissue (normally so densely granular) to look as if it were full of holes and gaps, nothing but a fine scarcely-visible reticulum remaining at certain points. The layer (*e*) of small ganglion-cells (pyramidal cells) shows this in the most marked way: the neuroglia may be hardly apparent (*f*), or it shows as a meshwork of glistening fibres (*e*) interlacing irregularly or disposed in stellate patterns. The points of intersection of the fibres are sometimes occupied by nuclei, and now and then it is possible to demonstrate that the fibres are simply processes of the neuroglia-cells. When the cortex is not visibly thinned the atrophy is slight and hardly to be made out in Canada-balsam preparations. Perosmic acid brings out the fact that some of the nerve-cells are breaking down, with or without the formation of fat-granules.

The medullary or white matter of the brain is often in these cases not only shrunken but also interspersed with foci of degeneration.

The cord and pia mater is in like manner subject to cellular infiltration: not infrequently there is also present some degeneration and sclerosis of the pyramidal and of the posterior columns (Arts. 647, 648).

In the disease known as **paralytic dementia** or progressive paralysis, which is characterised by loss of intellectual power, emotional derangement, and illusions, the atrophic form of haematogenous chronic meningoencephalitis

is an extremely common lesion. It must however be mentioned that not only this form but other chronic inflammations from traumatic injury of the head may lead to progressive paralysis, and that in patients who have died of the latter disease all that is found in some cases is simple non-inflammatory degeneration of the cortex and meninges. It would thus appear that the disordered nutrition and degeneration of the ganglion-cells and nerve-fibres is *the essential feature*; the inflammatory infiltration and the increase of the fibrous structures serve to indicate the nature of the process (Art. 657) but do not determine the clinical symptoms.

BAYLE describes progressive paralysis as a chronic arachnitis, CALMEIL as chronic periencephalitis, PERCHAPPE as softening of the brain, TUCZEK as chronic meningitis, MAGNAN as diffuse interstitial meningoencephalitis, MENDEL as diffuse interstitial cortical encephalitis, LUYS as diffuse interstitial sclerosis. Most writers regard the affection as an inflammation corresponding in general to what we have described as chronic meningoencephalitis. The interpretations given to the various morbid appearances differ widely. Thus MIERZEJEWSKY and VOISIN regard the fibrils and stellate cells, which are often so markedly visible in the atrophied cortex, as fibrinous. MENDEL, LUBIMOFF, SELVILI, and others attribute much importance to the stellate cells, and think that they multiply considerably. This can only occur in a very few cases and to a limited extent. As a rule they are not increased in number, but are merely more visible in the absence of the nerve-elements. The statements sometimes made as to multiplication of the ganglion-cells cannot be regarded as proven.

It is frequently asserted that in progressive paralysis the pia mater is abnormally adherent to the brain-surface, tearing away the latter as it is stripped off—but the test is of little value. It often fails where there is the most marked change both in pia mater and cortex, and only shows that the brain-substance is abnormally soft: the effect is in part at least due to post-mortem changes. It is better not to try at all to strip off the pia mater, for it renders the brain almost useless for minute examination afterwards.

MIERZEJEWSKY and others have affirmed that in this affection filamentous processes and ramified connective-tissue cells are found attached to the vessels of the cortex when isolated: the description is accurate, but the phenomenon is not characteristic, as it is found in connexion with other morbid conditions and even occasionally in healthy brains. SIMON, ARNDT, SCHÜLE, and GREIFF have found in paralytic and other brains patches of clear hyaline substance in the neighbourhood of the vessels.

According to TUCZEK (*Neurolog. Centralb.* 1883) in paralytic dementia the medullated nerve-fibres of the cortex are especially apt to be lost, and that chiefly in the island of Reil and Broca's convolution (left inferior-frontal); while the ascending-frontal gyrus, the paracentral lobule, the second-temporal gyrus, and the parietal and occipital lobes are usually free from change. The loss of fibres is first apparent in the superficial layers.

In one case of chronic basal meningitis MANZ (*Graefe's Arch. f. Ophthalm.* 1883) met with large endothelial growths in the pial sheath of the optic nerve, the nerve itself being atrophied.

On the morbid changes in the brain in progressive paralysis (general paralysis of the insane):—MEYNERT, *Viertelj. f. Psych.* 1868; WESTPHAL, *Arch. f. Psych.* I; SIMON, *ibid.* II; GREIFF, *ibid.* XIV; ZACHER, *ibid.* XIII, XIV; MESCHEDE, *Virch. Arch.* vols. 34, 56; TIGGES, *Allg. Zeitschr. f. Psych.* XX; SCHÜLE, *ibid.* XXV; LUBIMOFF, *Virch. Arch.* vol. 55, *Arch. f. Psych.* 1874; MIERZEJEWSKY, *Études sur les lésions cérébrales dans la paralysie générale* Paris 1875, *Arch. de physiol.* 1876; VOISIN, *Traité de la paral. gén. des aliénés* Paris 1879; MENDEL, *Die progr. Paral. d. Irren* Berlin 1880, *Berl. klin. Woch.* 1882, *Neurol. Centralb.* 1883; SCHULTZE, *Arch. f. Psych.* XI; SELVILI, *Zur path. Anat. d. Dementia paral.* In. Diss. Zürich 1876; LUYS, *Gaz. méd.* 33, 1876; KLEBS, *Prag. med. Woch.* 1879; EMMINGHAUS, *Allg. Psychopathologie* Leipzig 1878; TUCZEK, *Dementia paralytica* Berlin 1884; KRÄPELIN,

Arch. f. Psych. XV 1884; HARTMANN, *ibid.* XVI 1885 (mental disorder following injury to the head).

On like changes in the cord:—TÜRCK, *Wiener Sitzungsber.* LI, LII, LVI; WESTPHAL, *Virch. Arch.* vols. 39, 40; MAGNAN, *Gaz. des hôpitaux* 14, 1876; STEWART, *Glasgow Med. Journ.* 1886.

657. The **aetiology** of haematogenous chronic meningoencephalitis is in many respects imperfectly understood. Hereditary predisposition, severe mental labour, exciting or exhausting influences of every kind, etc. have all been observed as antecedent conditions, and in such cases the hypothesis of an infective or toxic exciting cause seems to be excluded: such a cause is conceivable only in cases where the process is associated with diseases like cerebrospinal meningitis, typhoid, erysipelas, articular rheumatism, etc. And even here the secondary affection may well be the result of disordered nutrition rather than of any special extension of the primary disease.

Most cases of chronic meningoencephalitis and meningomyelitis would thus appear to be in their inception mainly dependent on degenerative changes due to excessive functional activity or to disorder of the circulation.

In recent cases of mental disorder presenting the same symptoms as the lesion we are considering, that is to say in what is clinically progressive paralysis, the changes found are frequently degenerative only, little if any evidence of inflammatory disease being discoverable. White turbidity of the pia mater is the chief of these changes, and it is due to an accumulation in the tissue of small globules and granules of fat, fatty and broken-down cells, and occasionally fat-granule cells. This detritus cannot have been wholly produced at the points where it is found by the degeneration merely of the meningeal endothelium or of extravasated cells; it must at least in part be derived from the brain-substance: and as a fact like matters are found in small quantity in the pial sheaths of the cortical vessels, while the vessel-walls themselves show here and there spots of fatty degeneration. It is also of special interest to note that some of the ganglion-cells are likewise fatty.

It often happens that no signs of inflammation appear at the sites of degeneration, though there are often small haemorrhagic extravasations or pigmentary deposits to indicate that the circulation has been disturbed. It must be remembered that congestive hyperaemia alone, such as frequently accompanies excessive functional activity, is capable of increasing the intracranial pressure, and thus of compressing the capillaries, retarding the circulation, and bringing about local anaemia and engorgement with all their consequences.

But although simple disturbances of circulation and nutrition play an important part in the causation of progressive paralysis, it must not be forgotten that in other parts of the brain or cord,

such as the centrum ovale or the columns of grey matter, close examination may reveal collections of leucocytes in the adventitial sheaths of the vessels. These are sometimes very abundant, and can hardly be regarded as mere accumulations from stasis in the lymphatics, but are almost certainly evidence of inflammation. The occasional combination of multiple sclerosis (like that of recent encephalitis and myelitis) with meningoencephalitis is of interest as showing that the process is one which in some instances at least is not limited to the cortex, but affects the whole central nervous system. As the disease becomes more advanced, the evidences of inflammation become more numerous, a result probably of the continuous action of the same exciting causes as first induced it.

These observations hold of a number of the cases: in others the inflammatory nature of the lesion is apparent from the commencement. Some acute cases are indeed described in which *post mortem* the hyperaemia and saturation of the brain with liquid effusion were unmistakeable.

Chronic leptomeningitis is somewhat frequently associated with exudative pachymeningitis (Art. 664).

The apparent prominence of the neurogliar meshwork with its stellate cells in the atrophied portions of the cortex is at first due simply to the disappearance of the nerve-elements. Later on an actual multiplication and hyperplasia of the neuroglia-cells may take place, as in other atrophies of nerve-tissue.

The occasional combination of meningoencephalitis with degeneration and sclerosis of the posterior columns of the cord would indicate that the latter lesion is secondary, resembling in origin those changes we have already described. The spinal pia mater when it is affected at all is apt to be most thickened over the posterior half of the cord, and this has probably something to do with the locality of the sclerosis. The degeneration of the pyramidal tracts which is sometimes met with in the disease is perhaps dependent on the degeneration of the motor centres in the cortex (FLECHSIG), though this is questioned by WESTPHAL (Art. 647).

Chronic leptomeningitis of the cord alone, apart from the secondary forms dependent on inflammation of the dura mater, vertebrae, or cord-substance, is most commonly a termination of an acute attack. Most writers state that it may also be due to catching cold, and it sometimes follows mechanical injury. It is marked by the presence in the soft membranes of opacities, thickenings, and adhesions to the dura mater, and at times by increase and turbidity of the subarachnoid liquid. Marginal sclerosis, multiple sclerosis, and degenerations of some of the columns are occasionally present in the same case.

Cicatrisation and Sclerosis.

658. **Repair of wounds of the brain and cord.** Bruises, cuts, stabs, and gun-shot wounds of the brain are usually fatal from the supervention of purulent meningitis and encephalitis. More rarely abscesses are formed which are evacuated and healed up by granulation and cicatrisation. It is only when the wound is aseptic or is at once protected from septic infection that we can expect healing without suppuration.

The destructive changes set up by a traumatic lesion vary with its nature. Bruises and contusions are the most dangerous, stabs and punctures the least so.

When the brain is punctured (Fig. 274 *a*), as by a dagger-wound, in the first place haemorrhage takes place, and the tissue immediately contiguous is thereby destroyed. A patch of anaemic or haemorrhagic necrotic softening (*b*) is thus produced, the meninges overlying the part being usually infiltrated with blood.

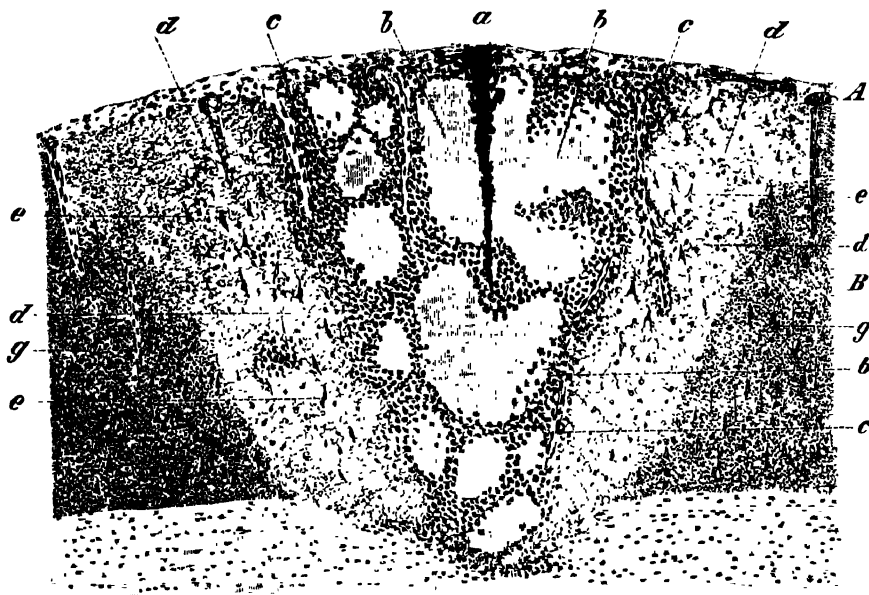


FIG. 274. ENCEPHALITIS EXPERIMENTALLY PRODUCED BY A PUNCTURE.

(*From a rabbit's brain 12 days after the injury: section hardened in Müller's liquid, stained with haematoxylin and neutral carmine, and mounted in Canada balsam:* × 25)

A meninges — *B* cortex — *C* white matter

a puncture
b necrotic tissue, granular and denucleated
c zone of inflammatory cellular infiltration
d zone of degeneration
e swollen and degenerate ganglion-cells
g normal cortical substance

At the boundary between living and dead tissue a more or less intense inflammation (*c*) sets in after a few hours, and this by degrees constitutes a zone of demarcation. The inflammatory process advances mainly along the vessels (*c*) entering from the pia mater, and in a few days the inflamed tissue softens and liquefies, while the inflammatory cellular infiltration extends more and more into the necrotic patch (*b*). The latter also liquefies and is absorbed, though months or years may pass before all the detritus is carried off.

Around the inflamed region the nerve-substance suffers from impaired nutrition, and a considerable portion of it undergoes degeneration (*d*), indicated by swelling, fatty change, fragmentation and disintegration of the ganglion-cells (*e*) and nerve-fibres. The inflammatory zone is thus surrounded by a broad zone of degeneration.

During the first few weeks the inflammatory zone is chiefly made up of vessels, small round-cells, larger formative cells, and fat-granule and pigment-carrying cells. The latter are always very abundant so long as absorption of the products of disintegration and extravasation goes on, the fat-granule cells being visible also in the zone of degeneration. After some weeks or months new fibrous tissue is gradually elaborated, plainly starting from the vessels that enter the inflamed region from the pia mater: the necrotic region is thus more and more surrounded and at length filled up with new-formed fibrous tissue. The fibres are sometimes close-set and wavy, sometimes loose and areolar, and are the product of the fibroblasts derived from the extravasated leucocytes and the connective-tissue cells of the pia mater and the vessel-sheaths.

This **cicatrisation** is a very slow process, and after months or years the scar may still contain multitudes of round-cells. The encapsuled necrotic patch only disappears after the lapse of many months, and the degenerative changes external to the inflamed region persist as long or longer. Rarely does the degeneration result in fibrous hyperplasia and sclerosis, though when this happens the sclerosis is apt to be very extensive. In like manner the fibrous thickening of the wounded pia mater often extends over a large area.

This is the process of repair in comparatively small wounds: it is of course modified if there has been extensive laceration of the brain-tissue. As we mentioned in Art. 645 in speaking of contusions, the development of fibrous tissue is apt to be slight and incomplete, and the process takes the form of progressive **ischaemic softening**.

This account of the repair of the wounds of the brain is based partly on observations made by the author on human injuries, partly on experiments made for him by KAMMERER upon rabbits. The process of healing can be readily followed in punctured wounds made under antiseptic precautions with recently heated needles. The oldest wound examined in a patient was 21 months old, and was due to a knife-stab penetrating the ascending-frontal

convolution of a young man. The necrotic patch was not then fully absorbed, and the scar was still surrounded by a broad zone of degeneration, which like the scar contained numerous fat-granule and pigment-carrying cells.

References:—BRUNS, *Die chir. Krankheiten u. Verletz. d. Gehirnes u. s. Umhüllungen* Tübingen 1854; STROMEYER, *Verletz. u. chir. Krankh. d. Kopfes* Freiburg 1864; BERGMANN, *Deutsche Chirurgie* part 30; VIRCHOW, *Virch. Arch.* vol. 50; GLUGE, *Abhandl. z. Physiol. u. Path.* Jena 1841 (experiments on encephalitis); HASSE and KÖLLIKER, *Zeitschr. f. rat. Med.* IV (1846); JOLLY, *Stud. aus d. Inst. f. exp. Path.* Vienna 1870; HAYEM, *Etudes sur les diverses formes d'encéphalite* Paris 1868; KLEBS, *Path. Anat. d. Schusswunden* Leipzig 1872; ZIEGLER, *Sitzungsber. d. phys.-med. Gesell. in Würzburg* 1878.

659. Both in the brain and cord we meet with localised or disseminated haematogenous inflammation, which like the localised degenerations lead partly to permanent loss of substance, partly to grey degeneration and sclerosis. **Encephalitis** is the name given to the affection of the brain, **myelitis** to that of the cord.

It is in the first place to be kept in mind (Art. 653) that in epidemic cerebrospinal meningitis patches of encephalitis and myelitis are of constant occurrence. In the meningitic processes associated with progressive paralysis inflammatory foci are found in the interior of the brain and cord, and sometimes in the pial sheaths of the nerve-roots. But these deeper inflammations also take place in the absence of meningitis, both in connexion with infective disorders and idiopathically.

Thus in typhoid, variola, acute rheumatism, pyaemia, puerperal fevers, ulcerative phthisis, etc. multiple encephalitis is not rare, while in hydrophobia (so-called *lyssa*) patches of inflammation scattered through the whole central nervous system, but chiefly in the base of the brain and the cord, have been described by a number of writers (KOLESSNIKOW, FOREL, GOWERS, WELLER). They are very common in tuberculosis (Art. 660).

Frequently too these patches occur without any apparent exciting cause, and are then attributed vaguely to cold or some such injurious influence. According to certain authorities violent irritation of peripheral nerves is capable of setting up myelitis; though it is more likely that the spinal diseases thus induced are due to ischaemic or haemorrhagic softening.

The smaller and more recent patches are not visible to the naked eye, being little more than circumvascular cellular infiltrations. When they are somewhat larger they are usually seen as red or pink spots, which are very distinct when in the white matter. Sometimes they contain little extravasations, and under certain conditions the whole patch resembles one of haemorrhagic softening.

The smaller patches occasionally heal without leaving a trace. In the larger ones there is always some destruction of nerve-tissue, a small cyst (Art. 642), a grey gelatinous patch (Fig. 271, Art. 650), a sclerosis, or a scar remaining after the cessation of the inflammatory disturbance and the absorption of detritus and exudation.

In the brain recent **multiple encephalitis** is found in many acute mental disorders: sometimes the patches are extraordinarily numerous. As to the issue of this form of the disease we know little, though it is possible that it terminates in multiple sclerosis. As to the larger myelitic foci and their consequences we are better informed.

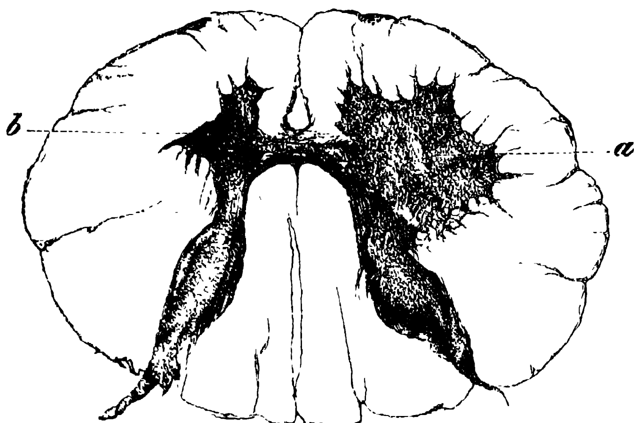


FIG. 275. SCLEROSIS AND SHRINKING OF THE LEFT ANTERIOR HORN.

(Section taken at the level of the fourth cervical nerve from a case of infantile paralysis (acute anterior poliomyelitis) in a child of $3\frac{1}{2}$: hardened in Müller's fluid, stained with neutral carmine, and mounted in Canada balsam: × 7)

a normal anterior horn with ganglion-cells
b atrophied and shrunken horn

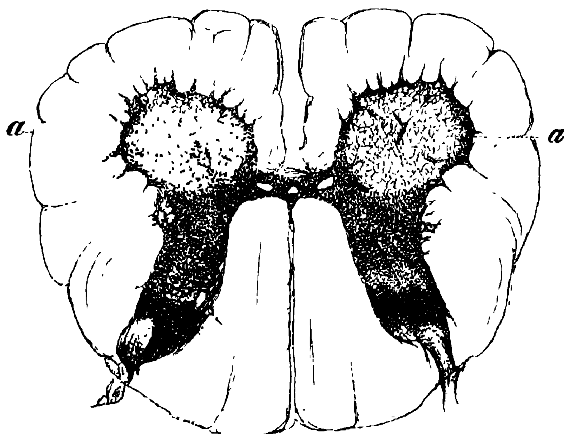


FIG. 276. GELATINOUS DEGENERATION OF BOTH ANTERIOR HORNS.

(Section taken from lumbar region: case of acute anterior poliomyelitis in a man of 40: preparation treated as in last figure: × 6)

a anterior horns

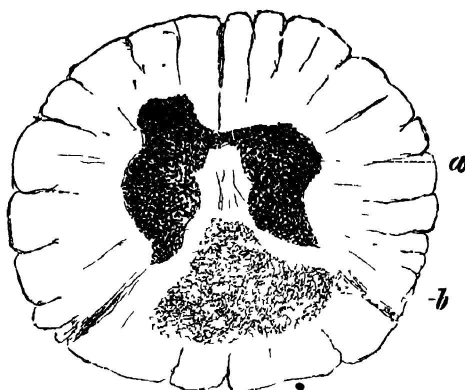


FIG. 277. SCLEROSIS AND SHRINKING OF THE ENTIRE GREY MATTER.

(*Section taken from lower dorsal region of a man of* 30 *suffering from acute anterior poliomyelitis: preparation treated as in last figure:* × 6)

a site of grey matter
b sclerosis of posterior columns.

In the first place the cord is subject to acute inflammation affecting chiefly the grey matter, and described as central myelitis or poliomyelitis (πολιος grey). **Anterior poliomyelitis** is the commonest form (Figs. 275, 276), the inflammation being limited to one or both anterior horns. More rarely it extends to the posterior horns or to the entire section of the grey columns (Fig. 277).

The disease chiefly attacks children less than four years old, and hence the clinical name of **infantile spinal paralysis**; it is rare in adults. Its onset is acute, there is usually fever, and soon paralysis, which in the course of a week passes away to some extent. So far as our knowledge goes the inflammation is haemorrhagic in character, and gives rise to functional disorder partly by destruction of tissue and partly by pressure. The preference shown for the anterior columns and especially for the inner two-thirds of each appears to be due to the fact that these parts constitute a special vascular territory distinct from the white matter. The length of the affected region varies from about 0·5 to 4 centimetres, though cases occur in which much larger segments of the cord are attacked.

The number of ganglion-cells and nerve-fibres destroyed depends on the severity of the inflammation: sometimes indeed the whole of the nerve-tissue perishes outright.

In the course of weeks or months the exudation and the products of disintegration are absorbed. If the neuroglia as well as the nerve-elements is destroyed a small cyst is formed. If the neuroglia persists and undergoes a moderate hyperplasia, the substance of the anterior horn is transformed into a grey gelatinous

mass (Figs 271, 276), consisting of a loose reticulum containing liquid in its wide meshes. When the hyperplasia is considerable the tissue becomes close-textured, firm, and sclerotic (Fig. 275), consisting of a felted mass of fine fibrils with scattered nuclei. The vessel-walls are in general thickened, the adventitial lymph-spaces are dilated, and contain at least in the earlier stages round-cells and granular cells When the nerve-elements are not entirely destroyed the sclerotic tissue still encloses a few ganglion-cells (Fig 278 *b*) and nerve-fibres.

The anterior roots and the peripheral motor nerves become atrophied when the ganglion-cells are destroyed, and assume a grey wasted appearance. The muscles supplied by them likewise atrophy.

When the inflammation affects the grey matter over its whole cross-section, the horns become after a time strangely warped and distorted, and presently undergo gelatinous degeneration or sclerosis (Fig 277).

The white columns are frequently affected by secondary extension of inflammation from the grey matter. Sometimes however the white matter is inflamed from the beginning, and we have **leukomyelitis** (λευκος white) associated with poliomyelitis. In such cases the whole cross-section of the cord or the greater part of it undergoes destructive inflammation (**transverse myelitis**), and afterwards gelatinous and sclerotic changes (Fig. 278). The

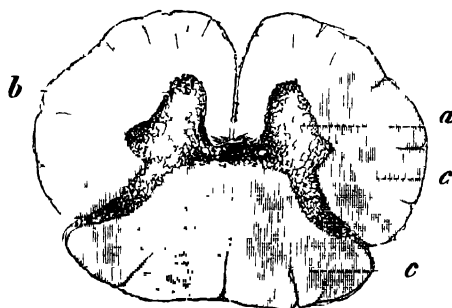


FIG. 278. SCLEROSIS AFTER ACUTE TRANSVERSE MYELITIS.

(*Section taken from a man of 40 at the level of the lower dorsal region hardened in Muller's fluid, stained with carmine, and mounted in Canada balsam.* × 6)

a gelatinous change in grey matter
b surviving ganglion-cells
c atrophied and sclerotic white matter

disease moreover frequently extends over a considerable segment of the cord. Secondary ascending and descending degeneration of the tracts after a time follows on the local lesion.

Myelitic foci are usually single, though sometimes they are multiple, as in disseminated myelitis. The multiple patches are usually small, and may be scattered throughout the whole cord.

When myelitis attacks the region of the bulbar nuclei it gives rise to acute **glosso-labio-pharyngeal or bulbar paralysis.**

Under conditions analogous to those which lead to acute poliomyelitis in children we may apparently have an acute inflammation of the cortical grey matter or **acute polioencephalitis** (STRUMPELL), the result of which is **infantile cerebral paralysis.** In its later stages it is characterised by loss of substance in the convolutions, resembling the congenital condition known as porencephalia (Art. 630).

BENEDIKT (*Virch. Arch.* vol. 64), KOLESSNIKOW (*ibid.* vol. 85), FOREL (*Zeitschr. f. Thiermed.* III), ALLBUTT (*Trans. Path. Soc.* XXIII 1872), GOWERS (*ibid.* XXVIII 1878), ROSS (*ibid.* XXX 1880), COATS (*Med. chir. Trans.* LXI 1878), and WELLER (*Arch. f. Psych.* 1879) all agree in stating that in **hydrophobia** circumvascular extravasations, some of them haemorrhagic, are found in the central nervous organs. BENEDIKT, KOLESSNIKOW, GOWERS, and WELLER also discovered circumvascular hyaline and granular coagulated masses formed from the extravasated elements of the blood, together with venous thromboses (BENEDIKT), and patches of 'granular' degeneration. FOREL was not able to verify these observations.

LANGHANS (*Virch. Arch.* vol. 64) found in the cord in cases of **tetany** certain circumvascular patches of cellular infiltration. NAUWERCK in a recent case of **chorea** minor with endocarditis observed small patches of inflammation situated chiefly in the medulla; these were combined with certain degenerative changes in the brain and cord. Myelitis is said to occur among the Kabyles in North Africa as a result of eating the pulse of *Lathyrus cicera*: see Art. 648, and MARIE (*Progrès médical* 1883), PROUST (*Bulletin de l'acad. d. méd.* XII 1884).

The number of white blood-cells usually present in the brain (Duke KARL THEODOR of Bavaria, *Virch. Arch.* vol. 69) is increased in typhoid (POPOFF), but not necessarily owing to inflammation. Sometimes, though rarely, disseminated encephalitis is associated with typhoid.

STEUDENER (*Beitr. z. path. Anat. d. Lepra mutilans* 1865), NEUMANN (*Skin diseases*, trans. by PULLAR, London 1871), TSCHIRJEW (*Arch. de physiol.* 1879), and LANGHANS (*Virch. Arch.* vol. 64) found inflammatory foci in the cord in connexion with anaesthetic leprosy. See also STURGE, *Brain* VII 1885.

ERB and others affirm that in infantile spinal paralysis the inflammatory disturbance extends over the whole of the anterior columns, reaching its greatest intensity only at certain parts, and the wide-spread initial paralysis corresponds with this view of the case. After weeks or months however only circumscribed changes can be demonstrated, the extent of which varies with the extent of the persistent paralysis. When certain muscles only are paralysed, certain spots only of the anterior horns are found to be degenerate.

References on myelitis:—CHARCOT, *Diseases of the nervous system* London 1880; LEYDEN, *Klinik d. Ruckenmarkskr.* 1874–76, *Zeitschr. f. klin. Med.* I, *Arch. f. Psych.* VI; HAMMOND, *Diseases of the nervous system* London 1876; ERB, *Ziemssen's Cyclop.* XIII; SCHULTZE, *D. Arch. f. klin. Med.* XX, *Virch. Arch.* vol. 68; DUJARDIN-BEAUMETZ, *De la myelite aigue* Paris 1872; WESTPHAL, *Arch. f. Psych.* III, IV (1874); HAYEM, *Arch. de physiol.* VI (1874); LAVERAN, *ibid.* VII (1875); BAUMGARTEN, *Arch. d. Heilk.* XVII; HAMILTON, *Quart. Journ. of micro. science* 1875; TURNER, and HUMPHREYS, *Trans. Path. Soc.* XXX 1879 (recent cases of poliomyelitis); DAMASCHINO and ROGER, *Gaz. méd.* 1871 (ditto); BARLOW, *On regressive paralysis* London 1878; ALTHAUS, *Infantile Paralysis* London 1878; ANGEL-MONEY, *Trans. Path. Soc.* XXXV 1884; DRUMMOND, *Brain* VII 1885; KRAUS, *Poliomyelitis anter. acuta* In. Diss. Tübingen 1882; SAHLI, *D. Arch. f. klin. Med.* XXXIII; ETTER, *Corresp. f. Schweiz. Aerzte* 1882 (acute bulbar myelitis); LANGE, *Hosp. Tidende* 1868

(ditto); LEYDEN, *Arch. f. Psych.* VII (ditto); LICHTHEIM, *D. Arch. f. klin. Med.* XVIII (ditto); EISENLOHR, *Virch. Arch.* vol. 73; VON VELDEN, *D. Arch. f. klin. Med.* XIX (disseminated myelitis); ENGELKEN, *Path. d. acuten Myelitis* In. Diss. Zürich 1867 (ditto); DRESCHFELD, *Lancet* 1, 1882 (ditto).

LEYDEN (*Arch. f. Psych.* VIII 1877, *Charité-Annalen* III) produced myelitis in dogs by injecting liquor arsenicalis (Fowler's solution) into the lumbar cord, and showed that the affection might terminate in cicatrisation, sclerosis, cyst, or in simple rarefaction or loosening of the tissue. He thought that disseminated multiple sclerosis was the result of a disseminated myelitis or encephalitis. Clinically the term myelitis is used in a sense much wider than that to which we have restricted it. Thus poliomyelitis is used to describe conditions which are not inflammatory, such as ischaemic and haemorrhagic softening, simple atrophy, and multiple sclerosis of the grey matter. Secondary and primary tract-degenerations, ischaemic and haemorrhagic softening, degeneration from pressure and contusion of the white matter of the cord or medulla oblongata, are all classed as myelitis. This may be convenient, but the pathologist is bound to be more discriminating. Even if it is not always possible in the post-mortem room to determine with certainty the manner in which a given change, say a patch of sclerosis, was initially induced, this is no reason for declining to classify such changes according to their mode of origin.

The terms acute and chronic progressive bulbar paralysis, anterior poliomyelitis, infantile spinal paralysis, atrophic spinal paralysis, transverse myelitis, leukomyelitis, protopathic and secondary spinal muscular atrophy, spastic spinal paralysis or paraplegia, and so on, are intended to express the character of the clinical symptoms and the seat of the lesion in the several maladies: for the most part however they fail to indicate or at least to indicate correctly the nature of the morbid process.

On acute polioencephalitis:—STRUMPELL, *Deut. med. Woch.* 1884, *Jahrb. f. Kinderheilk.* XXII 1885, *London Med. Record* 1885; GAUDARD, *L'hémiplégie infantile cérébrale* In. Diss. Geneva 1884; RANKE, *München. med. Woch.* 18, 1886; WOLFENDEN, *Practitioner* XXXVII 1886.

CHAPTER XCVI.

TUBERCULOSIS AND SYPHILIS.

660. **Tuberculosis** of the central nervous organs and their membranes is in most cases embolic in origin, though the disease may also extend by continuity from neighbouring tissues, such as the bones.

When the tuberculous virus reaches the brain or cord by way of the blood-vessels a form of tuberculosis is set up which we may call **disseminated tuberculous meningoencephalitis** or **meningomyelitis**. Where the bacilli first lodge their irritative action gives rise to minute inflammatory foci (Fig. 279, *c e f*), which in the subarachnoid and pia mater and in the substance of the brain and cord are distributed chiefly along the course of the small veins, in part also amid the capillaries of the nerve-substance itself. The pial sheaths (*f*) of the vessels are at first the chief seat of the inflammatory infiltration of cells; presently however the process extends also to the adjacent tissues (*e*). In a short time the collections of cells form nodules (*d*) and nodular clusters (*a b*), or more rarely larger continuous patches (*k*).

Disseminated embolic tuberculosis of the brain and cord runs in general a somewhat rapid course, and proves fatal in a few weeks' time. In addition to the nodular eruption there is often widespread diffuse inflammatory exudation of a sero-purulent or fibrino-purulent character, the pus infiltrating the meninges and the brain-substance, and often accumulating in the ventricles. It is only in rare cases and these very chronic (Fig. 279) that diffuse exudation fails to accompany an abundant eruption of tubercles.

In the soft membranes the first visible sign of tuberculosis is the appearance of small grey nodules usually lying along the course of congested vessels. By and by they become larger, and the subarachnoid spaces are seen to contain a turbid yellowish-white pus-like exudation. When the choroid plexuses are invaded they too contain grey nodules, and are swollen and infiltrated with a turbid liquid. The ventricles are more or less distended with the like exudation; sometimes they are enormously dilated, and the brain-substance thereby so compressed that the convolutions are

flattened and the subarachnoid liquid expressed, leaving the arachnoid surface dry.

The completely-developed tubercles in the nerve-tissue appear as little nodules, grey and translucent, or yellowish-white with a grey periphery. Quite recent continuous patches of tuberculous infiltration have a reddish tint, like other inflamed parts.

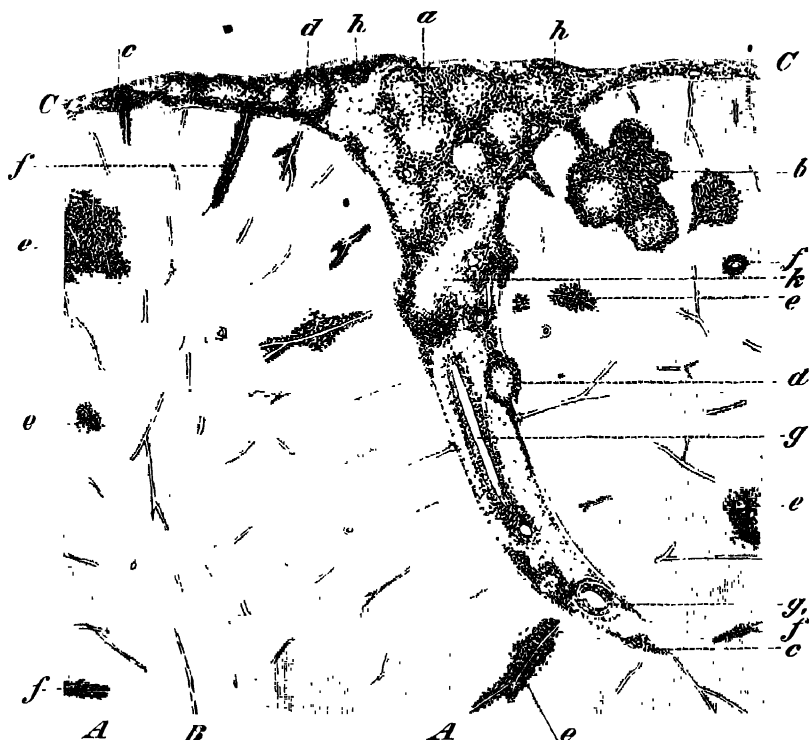


FIG. 279. CHRONIC DISSEMINATED TUBERCULOUS MENINGOENCEPHALITIS.

(Section hardened in Müller's fluid and alcohol, stained with alum-carmine, and mounted in Canada balsam: × 10)

A cortex *B* white matter *C* meninges

a dense fibro-cellular mass of tubercle in the subarachnoid tissue
b tuberculous mass in the cortex
c small tubercle in the pia mater
d isolated tubercle in the subarachnoid tissue
e circumscribed infiltration in the cortex, an early stage of tubercle
f cellular infiltration of pial sheath of cortical vessels
g g_1 longitudinal and transverse section of an artery
k diffuse fibro-cellular thickening of the subarachnoid tissue

Tubercles may appear in any part of the meningeal or nervous tissue. If growing near a vein they are seen to penetrate not only the adventitia but the inner coats, until the lumen of the vessel appears closely beset and encircled with the accumulated cells. The white blood-cells inside the vessel are often arranged peripherally, and sometimes visibly distend it.

Arteries running through tuberculous foci have first the adventitia invaded and infiltrated with cells; then the media and intima are attacked, especially the latter, which is sometimes so thickened by the infiltrating cells that the lumen of the artery is encroached on and obstructed. If then the white blood-cells gather at the diseased spot and form a thrombus the occlusion becomes complete.

Tubercles in the brain or cord very rapidly undergo caseation, and only in chronic cases (Fig. 279) are large formative cells developed in appreciable numbers: in such cases the mature tubercles assume the large-celled coarse-textured appearance of those growing in lymphatic glands (Art. 342). When caseation begins in a tuberculous focus lying near a vessel of moderate size it generally extends to the walls and to the cellular contents of the vessel.

The commonest seat of embolic tuberculosis is about the basal branches of the sylvian artery: the disease is generally bilateral, though often more extensive on one side than on the other, and cases are not wanting in which it is unilateral. When the bacilli reach the arterial branches that pass upwards from the sylvian fissure to the surface of the cerebrum they give rise to more or less extensive meningitis of one or both sides of the convexity.

The territory of the arteries of the median plane of the cerebrum, cerebellum, medulla, and cord may in like manner be infected, and though this does not occur so frequently as in the case of the basal regions it is by no means rare.

When the eruption is abundant the chief mass of tubercle is usually to be found in the soft membranes of the brain and cord; but the nerve-substance hardly ever escapes entirely. The disease of the pia mater extends to the cortex as a diffuse cellular infiltration, leading to destruction of the nerve-elements, often preceded by a remarkable swelling of the axis-cylinders and of the ganglion-cells. In like manner the cranial and spinal nerves are attacked, the cellular infiltration reaching the pial sheaths, and thence spreading along the fibrous septa into the substance of the nerves, and often inducing degeneration of the nerve-fibres.

In addition to this meningeal invasion we frequently meet with tubercles growing directly in the deeper parts of the substance of the brain and cord: even in cases described as tuberculous meningitis the number of encephalitic and myelitic foci is at times very considerable; they are overlooked simply because they are apt to be very small.

If the bacilli lodge in a few branches only of the meningeal or cerebral arteries the first eruption of tubercles is scanty. But as the patient does not usually die at once, the tubercles grow and coalesce into large masses lying beneath the pia mater or in the midst of the nervous tissues. In the subarachnoid spaces and in the pia mater they form flat discoid masses of various sizes, and in

the brain-substance rounded nodes, sometimes as large as a walnut or even a hen's egg. These are sometimes described as **solitary tubercles**. Their centres are yellowish-white and caseous, being sometimes firm and dense, sometimes soft and semi-liquid, rarely calcified. Their peripheral parts consist of greyish-red or semi-translucent granulation-tissue, often enclosing typical miliary tubercles.

The larger tubercles are developed from the smaller by the continued growth of new granulomatous tissue, sometimes containing multitudes of giant-cells, sometimes none at all. It is remarkable that where the inflammatory process is going on the fibrous elements of the brain-tissue often undergo marked hyperplasia, and form thus a coarse fibro-cellular tissue. Tubercle-bacilli can be demonstrated both in the grey granulomatous zone and in the older portions of the growth.

Solitary tubercles are most frequently observed in the cerebellum and cerebral axis. They act like tumours on the neighbouring tissues, giving rise to symptoms of pressure and to disturbance of the circulation both of blood and lymph. The other parts of the central organs may be entirely free from tubercle, though it often happens that tuberculous matter passes from the solitary nodes to the meningeal vessels and gives rise to disseminated and diffuse tuberculous meningitis. It is also of course possible for a fresh infection of the blood to take place, and in consequence a fresh embolic eruption of tubercles.

The situation of tuberculosis of the central nervous organs due to extension of tuberculous disease from contiguous parts is of course dependent on the seat of the primary affection. Tuberculous disease of the vertebrae infects the cord and its membranes, tuberculosis of the petrous bone extends in the first place to the temporal lobes and the basal aspect of the frontal lobe. Nodules appear in the affected regions, and these in time may grow into larger nodes. If the virus gain access to the cerebrospinal lymph-channels it may give rise to disseminated tuberculosis.

Many authorities (VIRCHOW, RINDFLEISCH, BIRCH-HIRSCHFELD, etc.) state that meningeal and cerebral tubercles lie usually in the adventitia of the arteries, and there form clusters of cells derived by multiplication from the endothelium of the lymphatics. They base this statement on the fact that in tuberculous meningitis collections of cells are found in the adventitia of the cortical arteries. This interpretation of the fact is however erroneous. The tubercles are developed from extravasated leucocytes and proliferous connective-tissue cells. The adventitia is affected and takes part in the proliferation only in a secondary way, and what has been described as a tubercle due to periarteritis of a pial vessel is in fact only a fraction of a tubercle growing near the vessel. In other inflammations of the pia mater and cortex we find like cellular infiltrations of the pial sheaths of the vessels, though it must not be overlooked that in tuberculous and syphilitic (Art. 661) inflammations the arteries take part in the cellular hyperplasia to a much greater extent than in other forms of inflammation. The like is true also of the endarteritic processes.

References :—VIRCHOW, *Cellular Pathology* London 1860, *Krankh. Gesch-*

wülste II Frankfort 1856; WILKS, *Path. Anat.* London 1875; RINDFLEISCH, *Virch. Arch.* vol. 24, *Path. Histology* II London 1873; HUGUENIN, *Ziemssen's Cyclop.* XII; VON CAMPE, *Beitr. z. path. Anat. d. meningit. u. meningo-encephalit. Processe* Tübingen 1882.

661. **Cerebrospinal syphilis** usually makes its appearance some years after the disease has become 'constitutional', that is to say, simultaneously with the so-called tertiary symptoms: it is rarely an accompaniment of the secondary symptoms. The characteristic morbid change is the formation of circumscribed inflammatory foci, or **gummata** as they are called, in the meninges and cortex, very rarely in the interior of the brain or cord. As a rule they lie in the pia mater and subarachnoid tissue of the base of the brain.

The first thing observed in the meninges is a small patch of inflammation, which soon leads to the formation of a grey or greyish-red semi-translucent or gelatinous knot of granulation-tissue (Fig. 280). In the earlier stages the tissue of the knot is

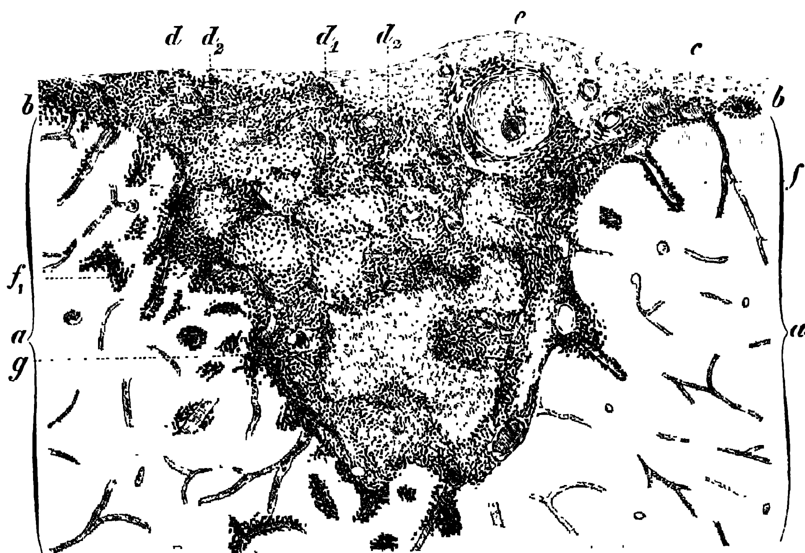


FIG. 280. GUMMATOUS SYPHILITIC MENINGOENCEPHALITIS.

(*Section hardened in Müller's fluid and alcohol, stained in alum-carmine, and mounted in Canada balsam:* × 15)

a cortex
b pia mater
c vein surrounded by cellular exudation
d recent and cellular, d_1 fibro-cellular, d_2 caseous granulation-tissue
e artery with thickened intima and infiltrated adventitia
f cellular infiltration of the pial sheaths of the cortical vessels
g diffuse infiltration extending into the cortical substance

extremely cellular (*f*), and contains a number of new-formed capillaries. As the process goes on some of the granulation-tissue becomes fibro-cellular (d_1), and some undergoes caseation (d_2). The adjacent brain-substance seldom or never remains intact, the

inflammation extending into the cortex along the pial sheaths of the vessels (*f*) and also directly (*g*). When arterial branches (*e*) pass through the granulomatous focus they are speedily infected, the adventitia, media, and intima becoming the seat of inflammation leading to cellular infiltration and fibro-cellular hyperplasia of the vessel-walls, according to the stage of the process. The intima (*e*) usually takes part to a remarkable extent in this hyperplasia, the thickening being often so great that the vessel is much obstructed or even occluded outright. The latter event is most apt to occur when thrombosis accompanies the endarteritis.

Gummatous foci may be either single or multiple. The single foci are sometimes very small; HEUBNER indeed has shown that the specific inflammation may be limited to single spots on the arterial walls, and there lead to the thickening of the intima just described. Larger foci are however more frequent, and are described as nodes or gummata simply. In the earlier stages they are grey or greyish-red and soft, their form depending on the texture of the tissue in which they lie. On the surface of the brain they follow the course of the sulci and take their shape: in the sylvian fissure they are flat and elongated: about the base of the brain and the cord they have irregular forms. Sometimes about the basal meninges the syphilitic inflammation is more diffuse and not nodular. When it extends to the brain-substance and grows in size the diseased patch becomes more and more globular, and at times is as large as a walnut, though the periphery usually remains somewhat irregular. The same holds for the nodes which develope independently in the substance of the brain and cord.

The smaller foci can undoubtedly disappear by re-absorption: the larger ones become partly indurated and partly caseous. The caseation begins with the appearance of yellowish-white opaque spots, measuring from a few millimetres to some centimetres across according to the size of the node itself. When several such spots appear in the same node they give it a mottled appearance, until at length coalescing they form a yellow centre to the mass. Induration generally goes on simultaneously with caseation, though sometimes the latter is absent. It leads to scar-like thickening of the meninges, and to adhesions between the pia and dura mater. The coarse scar-tissue generally encloses caseous patches.

Where syphilitic inflammation is going on the nerve-elements of course perish: the process is frequently associated with ischaemic and haemorrhagic softening of adjoining parts, consequent on the disturbance of the circulation induced by arteritis and compression. Occasionally these degenerative changes extend widely. Nerves passing through the inflamed region undergo inflammatory infiltration, and thereafter becoming enclosed and beset by coarse fibrous tissue they speedily atrophy and break down. Thus gummatous inflammation of the meninges at the lower end of the

cord now and then leads to the enclosure of the greater number of the nerves of the cauda equina in a mass of granulation-tissue: this is presently transformed into a coarse cicatrix, and blended by adhesions with the dura mater forms a compact mass of scar-like tissue enclosing atrophied nerves and caseous patches. The same thing sometimes happens in the case of the cranial nerves.

Some nodes of the brain and cord which have been described as gummatous appear beyond a doubt to have been tuberculous. As the periphery and the neighbourhood of these nodes do not always contain tubercles, before the discovery of the tubercle-bacillus it was not always easy to determine the nature of a given caseous mass. VIRCHOW has asserted that tuberculous nodes are rounded, while gummatous ones are irregular; but this criterion does not always hold good.

References:—VIRCHOW, *Virch. Arch.* vol. 15, *Krankhafte Geschwülste* II 1869; LEON GROS and LANCEREAUX, *Des affections nerv. syph.* Paris 1861; ENGELSTEDT, *Die constitut. Syphilis* Wurzburg 1861; WILKS, *Guy's Hosp. Rep.* IX (1863); WAGNER, *Arch. d. Heilk.* IV (1863); WESTPHAL, *Allg. Zeitschr. f. Psych.* XX (1863); JAKSCH, *Prag. med. Woch.* 1864; LANCEREAUX, *Traité de la syphilis* Paris 1866 (trans. New Syd. Soc. II London 1869); HEUBNER, *Arch. d. Heilk.* XI (1870), *Die luetische Erkrank. d. Hirnarterien* Leipzig 1874, *Ziemssen's Cyclop.* XII; GREENFIELD, *Trans. Path. Soc.* XXVIII, XXIX; CHARCOT and GOMBAULT, *Arch. de physiol.* V 1873; BRAUS, *Die Hirnsyphilis* Berlin 1873; BRUBERGER, *Virch. Arch.* vol. 60; WILKS and MOXON, *Path. Anat.* London 1875; BROADBENT, *Lancet* 1, 1874; BAUMGARTEN, *Virch. Arch.* vols. 73, 76, 86; VON RINECKER, *Festschrift z. Jubil. d. Wurzburg. Universität* 1882; GREIFF, *Arch. f. Psych.* XII; FOURNIER, *La syph. du cerveau* Paris 1879, *Leçons sur la syph.* (2nd edition) Paris 1881; JULLIARD, *Etude critique sur les localis. spin. de la syph.* Paris 1879; WESTPHAL, *Charité-Annalen* I (1876); GOWERS, *Hill and Cooper's Syphilis* London 1881; BUZZARD, *Lancet* 1, 1873 and *Brain* III 1880, *Diseases of the nervous system* London 1882; DOWSE, *Syphilis of the brain and spinal cord* London 1881; ROSENTHAL, *D. Arch. f. klin. Med.* XXXVIII 1886 (with numerous references).

CHAPTER XCVII.

TUMOURS AND PARASITES.

662. Of the tumours occurring in the brain and spinal cord the **gliomata** (Art. 145, Fig. 40) claim our first notice. They are commonest in the cerebrum, more rare in the cerebral axis and in the cord: they lie usually close beneath the pia mater. In most cases the outer aspect of the brain-surface remains unaltered, the tumour appearing merely to cause enlargement and discoloration of the affected part, and perhaps some thickening of the meninges. It is seldom that the tumour takes the form of a definite protuberance.

On section the neoplastic mass consists sometimes of tissue not a little resembling pale or hyperaemic grey matter in tint and consistence: more commonly however the glioma is grey, greyish-white, greyish-red, yellow, or gelatinous in appearance, or mottled with all these tints and with spots of opaque white and of extravasated blood (Fig. 281 *b*); its consistence is in parts softer, in parts firmer than that of normal brain-tissue. Frequently it includes numerous vessels distended with blood, and of markedly larger calibre than the ordinary vessels of the part. When the haemorrhages are numerous and extensive they may so stain and disguise the tissue that it looks like a patch of apoplectic extravasation. If the tissue is partly destroyed either by haemorrhage or by softening the growth encloses cavities filled with turbid white or brown semi-liquid detritus.

Cerebral gliomata measure as much as 3 to 8 cm. across, or even more. The surrounding brain-substance is sometimes scarcely marked off from the substance of the tumour, sometimes is quite distinct and even visibly compressed: not infrequently it is softened and may contain cysts of disintegration. The ventricles are as a rule more or less dilated.

In the cord gliomatous tumours usually lie close to the central canal and spread thence posteriorly and externally. They are in general elongated, seldom globular, and may extend over a considerable length of the cord. Externally they give the cord a

bulging or thickened appearance. Dilatation of the central canal and excavation of the growth itself are common (syringomyelia, Art. 635).

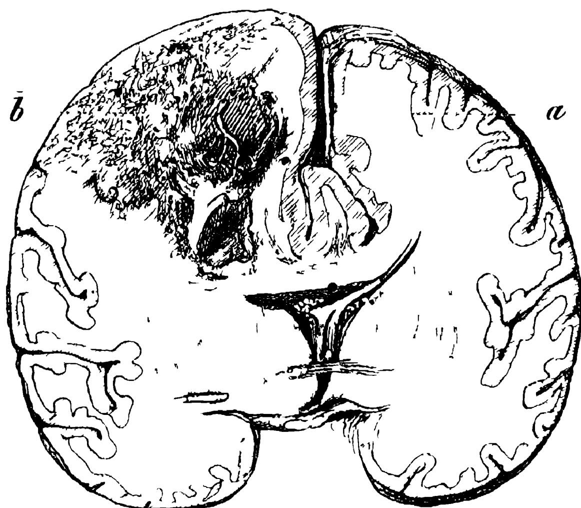


FIG. 281. ANGIOMATOUS GLIOMA.
(*Frontal section through the brain*)
a right hemisphere *b* glioma in left hemisphere

As we have mentioned in Art. 145 the tumour is made up of branched neuroglia-cells, though the number and size of the cells present in different growths is subject to great variation. When they are small and scanty, and their ramifying fibrils numerous and closely felted, the texture is dense and firm: when the cells are large and numerous the tumour rather resembles a sarcoma.

The cells are in general uniformly scattered through the mass, but now and then they appear to lie in small clusters: multinuclear cells are common, especially in the peripheral parts of the growth.

The vessels are frequently much dilated (Fig 41), and so abundantly developed that the tumour is fitly described as telangiectatic or angiomatous. The vessel-walls are often thickened and hyaline, and there is hyperplasia of the adventitia, the vessels being thus surrounded by a thick envelope of cellular and fibro-cellular tissue. Round the veins there may be accumulations of white blood-cells.

The tumour grows by proliferation of the neuroglia and multiplication of its cells: at least this is as much as can be made out by examination of the growing margin. The nerve-fibres as they are encroached on perish, their axis-cylinders becoming notably swollen before they break down. The ganglion-cells and their nuclei also swell in a remarkable way, and become homogeneous and glassy in appearance. Later on they break down like

the nerve-fibres, though it is sometimes surprising how long both elements persist.

When the glioma presses on the pia mater the connective-tissue cells of the latter undergo subdivision and multiplication, and a new-formation of fibrous tissue usually takes place. The gliomatous growth may ultimately extend into the meshes of the fibrous tissue. In ischaemic and haemorrhagic softening of the growth the cellular elements perish, partly by necrosis and partly by fatty degeneration. Sometimes peculiar protoplasmic lumps, with or without nuclei, are produced, apparently by coalescence of some of the cells. Stratified corpora amylacea also occur in the tumour-tissue.

Sometimes a mucous liquid forms abundantly in the interstices of a glioma and give it the appearance of loose mucous tissue: such tumours are described as **gliomyxomata**. Still more frequently the connective-tissue cells undergo so marked a proliferation that the tumour becomes a **gliosarcoma**, the neuroglia-cells increase greatly in number and size, and ultimately lose their typical characteristics. In other cases the vascular adventitia becomes abnormally proliferous, and the product of its overgrowth is at length so abundant that the gliomatous structure is overshadowed. Gliosarcoma is chiefly characterised by the multiform character of its cells; but the overgrowth just alluded to results in a spindle-celled neoplasm, the cells being arranged along the course of the blood-vessels: it is therefore described as **angiosarcoma**. Sarcomatous transformation in a cerebral glioma gives the tumour a marrowy or 'encephaloid' consistency, and marks it off more sharply from the surrounding brain-substance.

Sarcoma also occurs as an independent growth, unattended at first by any multiplication of neuroglia-cells. Spindle-celled and multiform-celled varieties are the commonest, and they are in general soft and marrowy. They are commonly rounded, sharply defined, of all sizes, and either single or multiple. So far as we at present know they develope from the pial sheaths of the vessels and in part from the neuroglia. Haemorrhage and softening of the tumour are frequent. If it lies close beneath the pia mater it often invades that membrane. The surrounding brain-substance is generally softened, the meninges inflamed, and the ventricles dilated.

Small **angiomata** are not uncommon in the brain, though they do not form regular tumours but only small reddish foci, not unlike recent patches of inflammation. They are probably congenital (VIRCHOW), and are of the same nature as vascular naevi. There is simply telangiectasis of the blood-vessels, not cavernous metamorphosis of the tissue (Art. 149). GANGUILLET recently described as **cylindroma** a gelatinous-looking angioma of the lower end of the spinal-cord: it was composed of vessels whose adventitia had become hyaline, and was beset with bulging hyaline outgrowths (Art. 163, Fig. 57).

Fibroma of the central nervous organs is rare: it forms rounded nodes, which in the cord and roots of the spinal nerves are sometimes multiple, especially in cases of multiple fibroma (neurofibroma) of the peripheral nerves (Arts. 154, 399, 670).

BIDDER mentions a case of **osteoma** in the corpus striatum; it measured several centimetres in diameter. MESCHEDE met with a bony growth in the cerebral hemisphere of an epileptic. BENJAMIN describes a **lipoma** in the cerebrum.

Secondary growths, sarcomatous and carcinomatous, occur in the brain as in other organs: they usually form rounded nodes or nodules.

KLEBS maintains (*Viertelj. f. prakt. Heilk.* 125, 133) that the ganglion-cells take an active part in the production of gliomatous neoplastic cells, and HELLER (*Naturforscherversammlung in Freiburg* 1883) agrees with him. The author has gone over again his preparations of glioma, but is unable to find any ground for altering the view expressed in Art. 145. The ganglion-cells do indeed swell up considerably, and occasionally a binuclear cell can be seen; but that is all. As the tumour developes the ganglion-cells break down, and the clusters of neuroglia-cells afterwards found in their place are evidences merely that the latter have multiplied in their neighbourhood.

As we remarked in Art. 651 it is not possible to draw a sharp line between glioma and sclerosis. This is especially true of the gliomatous growths occurring round the central canal of the cord, but it also holds of cerebral glioma. Sometimes part of the neoplastic change will appear to be essentially due to increase and induration of the connective tissue, while close by there is an unmistakeable sharply-defined tumour.

Probably the smallest sarcomata of the central nervous organs hitherto described were observed some time ago by the author and Dr ANDREAE in the cord of a lady who had suffered from some ill-defined disturbance of the innervation of the left arm: two nodules of spindle-celled sarcoma 2 and 3 mm. in diameter respectively were found in the left anterior horn of the cervical cord. The author has met with numerous small fibromatous nodules in the nerve-roots and the cord of a patient suffering from multiple fibroma of the peripheral nerves.

References: VIRCHOW, *Krankhafte Geschwülste*; SCHUPPEL, *Arch. d. Heilk.* VIII 1867 (glioma and gliomyxoma of the cord); K. HOFFMANN, *Zeitschr. f. rat. Med.* XXXIV 1869 (glioma); NEUMANN, *Virch. Arch.* vol. 61; TH. SIMON, *ibid.* vol. 61; GOLGI, *Cent. f. med. Wiss.* 1875; KLEBS, *loc. cit.*; GANGUILLET, *Beitr. z. Kenntniss d. Rückenmarkstumoren* Berne 1878; PETRINA, *Prager Viertelj.* 133, 134; ROTH, *Arch. de physiol.* 1878 (diffuse glioma of the cord); MESCHEDE, *Virch. Arch.* vol. 35; BIDDER, *ibid.* vol. 88; LEBERT, *Traité d'anat. path.* II; CORNIL and RANVIER, *Man. Path. Hist.* I London 1882; BENJAMIN, *Virch. Arch.* vol. 14 (lipoma of cerebrum); SCHULTZE, *Arch. f. Psych.* VIII (periependymal angiomatous gliosarcoma of the cord); MEYER and BAYER, *Arch. f. Psych.* XII (relation of encephalitis to glioma); GERHARDT, *Festschrift d. Universitat Würzburg* 1882 (glioma); OSLER, *Journ. of Anat. and Physiol.* XV 1881 ('neuroma' of the brain, rather a heterotopia); REISINGER, *Virch. Arch.* vol. 98 (glioma of the cord); GLASER, *Arch. f. Psych.* XVI (angiosarcoma of the cord); RENAUT, *Gaz. méd. de Paris* 1884 (cerebral glioma); BARD, *Les tumeurs du type nerveux*, *Arch. de physiol.* V 1885.

663. The **tumours of the internal meninges**, the telae choroideae, and the lining membrane of the ventricles are chiefly of the mesoblastic or connective-tissue type, but epithelial or carcinomatous growths are also met with.

In the first place we have a group belonging to the **sarcomata** which form soft nodes, or less frequently broad flattened growths. Their section is marrowy, greyish-white or greyish-red in tint, sometimes almost gelatinous. They are commonest about the base of the brain, more rare on its convexity, still rarer in the pia mater of the cord and telae choroideae of the ventricles: they are either entirely confined to the meninges or encroach somewhat on the nerve-substance.

So far as investigations have shown they originate partly in the adventitia of the vessels and partly from the (endothelial) cells which cover the fibrous trabeculae of the arachnoid, subarachnoid, and pia mater. The new-formed cells become highly developed, and resemble the multiform epithelial cells of carcinoma. As they lie in a stroma composed of the meningeal tissues and form dense clusters in its meshes. which look exactly like nests of cancer-cells, the tumour has the appearance of a carcinoma and is often so described. It is however strictly speaking an **alveolar sarcoma** (nested sarcoma) in type, and its structure and the grouping of its endothelial cells justify us in classing it with the endotheliomata (Art. 161).

Endothelioma appears to be the commonest growth met with in the soft membranes, but others also occur from time to time which must be classed as ordinary **sarcoma**, **myxosarcoma**, and **myxoma**; the latter is chiefly found in the pia mater of the cord.

The blood-vessels of sarcomatous and myxomatous growths sometimes develope in number and size until they transform these into what we must call angiosarcoma, angiomyxoma, and angiomyxosarcoma. The vessels are wide and thin-walled or narrow and thick-walled, and form networks and complicated coils. The intervascular tissue may be simply fibrous, or mucous, or sarcomatous. If it is scanty the tumour assumes the aspect of a simple **angioma**.

Fibroma, lipoma, and chondroma are rare; but they do occur in the meninges and ventricular plexuses, forming small nodular or lobulated tumours which compress the nervous tissue. Seated at the lower end of the cord they sometimes encircle and compress the nerves of the cauda equina, and lead to their atrophy and degeneration.

Another rare growth in the pia mater consists essentially of a coarse fibrous stroma containing wide cysts or cavities filled with lymph. It looks somewhat like a piece of oedematous tissue, but is distinguished therefrom by the abundant development in it of fibrous tissue, which marks it off sharply from the surrounding structure and forms thick septa between the cysts. It is thus a true neoplasm and might be described as cystic lymphangioma or **cystic fibroma**.

In all these growths, but especially in myxoma and in fibroma,

calcification may set in, and alter the vessels or lead to an increase of the so-called **brain-sand.**

Calcareous plates are often formed in the otherwise unaltered pia mater; and in the ventricular plexuses the brain-sand may be so increased that the plexuses are visibly enlarged and turn an opaque white.

In tumours the like occurs, in combination with calcareous degeneration of the vessels. When the accumulation of calcareous matter in the growth is very great we have what is called **psammoma.** The organic basis of brain-sand consists of flattened cells which cohere like the coats of an onion, become homogeneous and lose their nuclei, and then are calcified.

Carcinomata are found in the ventricles, and form soft tumours (Fig. 282 *a*), usually connected with the plexuses and originating in their epithelium or (more rarely) in that of the ependyma. The cancer-cells (Fig. 283 *a*) lying in a fibrous stroma are of the cylindrical or columnar type. By the outgrowth of the vascular stroma into papillae the tumour sometimes assumes a papillomatous appearance (Fig. 283).

If as not infrequently happens the stroma undergoes partial mucoid degeneration (Fig. 283 *b c* c_1) the tumour exhibits a very peculiar structure. The papillary outgrowths are transformed into

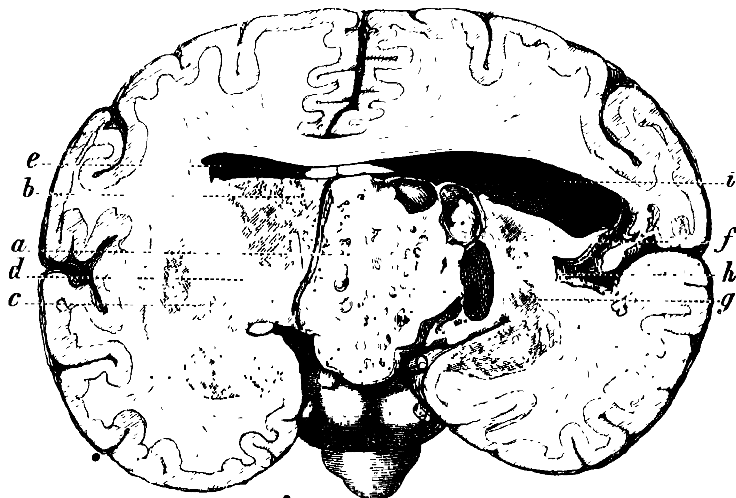


FIG. 282. PAPILLOMATOUS CARCINOMA OF THE CHOROID PLEXUS.

(Frontal section through the third ventricle)

a tumour with cysts
b right optic thalamus
c right lenticular nucleus
d right internal capsule
e right corpus striatum
f left optic thalamus
left lenticular nucleus
h left internal capsule
i dilated left lateral ventricle

cysts (Fig. 282, Fig. 283 *d*) separated merely by stings of epithelial cells (*e*), so that the epithelium forms a kind of stroma enclosing cysts formed of connective-tissue. **Epithelial pearls**, or concentric globes (*h*), are sometimes formed in the midst of the masses of epithelium, and look wonderfully like those met with in cutaneous cancers (Art. 172), while contrasting sharply with the cylindrical cells of the growth.

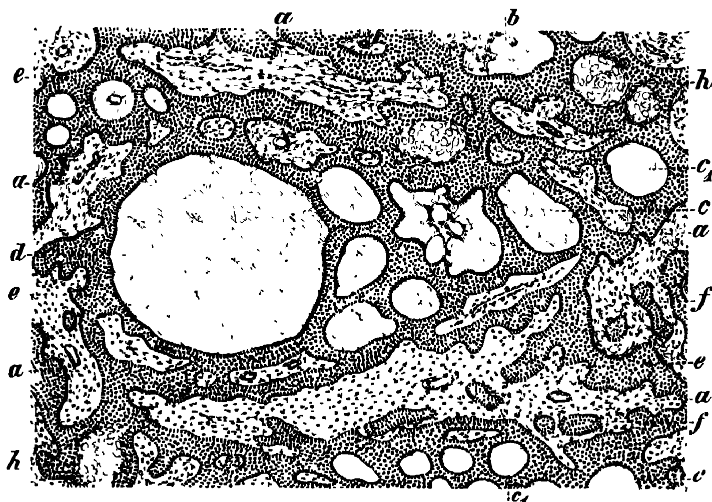


Fig. 283. Papillomatous carcinoma with gelatinous degeneration of the stroma from the third ventricle.

(*Section hardened in Müller's fluid, stained with alum-carmine:* × 25)

a fibrous stroma with blood-vessels
b partially mucoid papilla
c mucoid papilla coagulated by the hardening fluid
c_1 hyaline masses
d cyst in degenerate stroma, with coagulated contents
e f interpapillary strings and nests of cells
h epithelial pearls

The tumour is usually confined to the ventricle, and leads to compression of the brain-substance (Fig. 282 *f g h*) and ventricular dropsy (*i*). It may however invade the brain-substance, and give rise to secondary nodules (Spaet). It is not certain whether this form of tumour occurs as a primary growth in any other region, but it is quite possible that it may arise say about the anterior or posterior transverse fissure, or at the base of the brain near the infundibulum: it probably developes from aberrant germinal epithelium (Art. 181).

Cholesteatoma, or pearly tumour, is one whose mode of origin is not well understood: it is a growth characterised by the presence in it of white rounded 'pearls' with a nacreous lustre. It occurs chiefly in the dura mater of the base of the brain about the transverse fissures, but it is also found in the interior of the organ. The soft white mass of the growth consists mainly of epithelial

scales like those of the epidermis. Most authorities assume its endothelial origin; but it seems more likely that its 'pearls' are derived from the epidermic epithelium of the medullary tube, and are thus connected by descent with the external surface. Moreover in rare cases (ZIEGLER) minute hairs have been found in the mass: and the situation of the tumour points in the same direction, for the places described are such that at the time of the development of the brain primitive epiblastic cells might well remain unelaborated, and form the rudiment of a neoplasm at a later stage (Art. 181).

Secondary growths of every kind occur in the meninges. It is worth noting that they sometimes spread far and wide in the subarachnoid spaces. Thus a metastatic cancer of the pia mater in the vertebral canal may in course of time encircle the greater part of the cord and infiltrate the cauda equina.

Of **animal parasites** the *Echinococcus* and *Cysticercus* are found in the brain and cord. The former takes the form of single or multiple hydatid vesicles of various size, which compress the nerve-substance and lead to softening. The *Cysticercus*, or measle, is commonest in the meninges of the brain, and appears either in the usual form as a small cyst with its scolex, or as the *Cysticercus racemosus*, a cluster of large lobulated usually sterile vesicles grouped like grapes around a parent cyst (Arts. 243, 245).

We may here make mention of some formations which are not strictly tumours, though in some points resembling them.

Aneurysms of the basilar arteries are very common, and reach a considerable size (see LEBERT, *Berl. klin. Woch.* 1866). **Varices** are developed chiefly in the pial veins of the cord, and sometimes become so large that they form vascular knots like haemorrhoids, which compress the cord and lead to its degeneration. In the cerebral ventricles are found small nodules seated on the ependyma: they are simply compact **fibrinous deposits** which have become partially organised and contain formative cells and capillaries.

Many of the growths described as cerebral cancer or epithelioma have no claim to the title. EBERTH's and ARNDT's epitheliomata of the pia mater were cases of alveolar sarcoma; only those alveolar neoplasms in the development of which the epithelium of the medullary tube is concerned are to be reckoned as carcinomata.

CORNIL and RANVIER state (*Man. Path. Hist.* I London 1882) that brain-sand arises from buds or off-shoots from the vessels, which are made up of flattened cells and presently become calcareous. They therefore describe the tumours which are characterised by the abundant presence of the sand as **angiolithic sarcomata**. It is doubtful whether all brain-sand is of this kind.

References on tumours:—VIRCHOW, *loc. cit.;* MULLER, *Virch. Arch.* vol. 8 (cholesteatoma), vol. 16 (melanoma); ROKITANSKY, *Handb. d. path. Anat.* II (cholesteatoma, angioma); LEBERT, *Maladies cancéreuses* Paris 1851; PARROT, *Arch. de physiol.* 1869 (lipoma); MORRIS, *Trans. Path Soc.* XXII (angioma); WILKS and MOXON, *Path. Anat.* London 1875 (chondroma); ROBIN, *Journ. de l'anat. et de la physiol.* 1869 (endothelioma); J. ARNOLD, *Virch. Arch.* vol. 51 (cystic sarcoma telangiectodes); EBERTH, *ibid.* vol. 49 (endothelioma); ARNDT, *ibid.* vol. 51 (endothelioma); MESCHEDE, *ibid.* vol. 35 (osteoma); KLEBS, *loc. cit.*; EPPINGER, *Prager Viertelj.* 1875 (cholesteatoma); SPAET, *Primärer multipler Epithelkrebs d. Gehirns* Munich 1882; RINDFLEISCH, *Path. Hist.* II London 1873; BERNHARDT, *Beitr. z. Symptom. u. Diagnost. d. Hirngeschwülste* Berlin 1881; GANGUILLET, *loc. cit.* (sarcoma of spinal pia mater); LEYDEN,

Klinik. d. Rückenmarkskr.; ERB, *Ziemssen's Cyclopaedia* XIII; FALKSON, *Virch. Arch.* vol. 75 (chrondrocystosarcoma of choroid plexus); LACHMANN, *Arch. f. Psych.* XIII (glioma of the filum terminale); DRESCHFELD, *Journ. of Anat. and Physiol.* XIV 1879 (psammoma); BILLROTH, *Arch. d. Heilk.* III (myxoma of pia mater of cerebellum); CHIARI, *Prag. med. Woch.* 1883 (cholesteatoma of dorsal cord); LANCEREAUX, *Traité d'anat. path.* II.

On *Cysticercus racemosus*:—VIRCHOW, *Virch. Arch.* vol. 18; HELLER, *Ziemssen's Cyclopaedia* III; MARCHAND, *Virch. Arch.* vol. 75, *Breslau. ärztl. Zeitschr.* 1881; ZENKER, *Ueb. d. Cyst. racem. d. Gehirnes* Erlangen 1882, *Henle's Beiträge* Bonn 1882; GRIESINGER, *Arch. d. Heilk.* III 1862 (with references); FERBER, *ibid.*

On hydatids of the brain see the works of COBBOLD, DAVAINE, etc. (Arts. 245—248).

CHAPTER XCVIII.

THE DURA MATER, PINEAL BODY, AND PITUITARY BODY.

664. The **dura mater** is a stout fibrous membrane, closely adherent to the inner surface of the cranium, and dividing into two laminae at the foramen magnum: one of these lines the vertebral canal, the other forms a sack-like investment for the spinal cord, the intervening space containing loose connective tissue, fat, and blood-vessels, in particular the venous plexuses.

Where the dura mater adheres to the bone it serves as its periosteum, and is liable to all the morbid changes that affect the periosteum of other bones. Certain special dangers also arise from its connexion with the central nervous system, and these require separate consideration.

In the first place the dura mater is very frequently the seat of an inflammatory process known as **chronic internal pachymeningitis**, the result of various injurious agencies whose exact nature is not fully understood. The inflammation is usually haematogenous, and is associated either with inflammation of the pia mater and subarachnoid tissue on the one hand or with disease of the bones on the other. It is commonest in the cerebral dura mater, and may be unilateral and circumscribed, or bilateral and in scattered areas or generally diffused.

The first morbid sign is the appearance of very thin fibrinous deposits on the internal surface of the membrane: these consist of scanty liquid and cellular exudations from the dural vessels. After a time the fibrin becomes organised, or in other words pervaded by living cells and new-formed vessels growing as off-shoots from the inflamed capillaries. A delicate fibrous tissue is thus elaborated, which lines the dura mater as a semi-transparent vascular membrane.

The new-formed vessels have very thin walls and are particularly prone to bleed, the slightest disturbances of the circulation apparently sufficing to set up **haemorrhage** by rupture or diapedesis. The consequence is that pachymeningitic membranes nearly always contain recent extravasations and pigmented deposits testifying to

past haemorrhage: this peculiarity has led to the affection being described as **haemorrhagic pachymeningitis**. The extravasations are usually small, but now and then they are so extensive that they separate the false membrane from the dura, and form blood-cysts or **haematomata**, which may cause grave compression of the brain. If the cyst gives way blood will of course escape into the subdural spaces.

Once the inflammation has begun it seldom attains to complete resolution and recovery. The extravasated matters are by degrees re-absorbed, but if they are at all abundant the process is very slow and imperfect, and their continued presence keeps up an irritation that induces renewed inflammation. New exudations and new membranes are thus produced, and at length a dense scar-like tissue results, which contains masses of pigment, fibrinous residues, and calcareous matters. Sometimes after resorption of a haemorrhagic extravasation a localised collection of liquid appears between the dura and the cicatrised membrane: this has been called **hygroma of the dura mater**, or partial pachymeningitic hydrocephalus. In older denser and more fibrous membranes some of the vessels are gradually occluded by contraction, but other parts remain highly vascular, and fresh haemorrhages keep up the chronic inflammation.

Pachymeningitic membranes do not usually adhere to the arachnoid; but when this happens the new-formed vessels pass down into the internal meninges.

There is also an **external chronic pachymeningitis** in which the changes are chiefly limited to the cranial surface of the dura mater: they consist of thickening of the membrane and absorption or hyperplasia of the bone. Moreover, the dura mater is frequently inflamed by extension of mischief from contiguous parts. Thus suppuration due to an infected wound of the skull may involve the dura mater (Art. 654); and otitis media or inflammation of the petrous bone or of the vertebrae or the interdural tissue frequently extends to this membrane. When suppuration takes place the dura has a discoloured yellowish-white or greyish-yellow appearance: if the suppuration is preceded by haemorrhage the tint may be greyish-green or brown.

Tuberculosis arises as a concomitant of embolic tuberculous leptomeningitis or of tuberculous bone-disease. The inner surface of the dura is beset with disseminated grey tubercles, while in more advanced stages pachymeningitic membranes containing tubercles, or large granulomatous vegetations, or caseous foci are found. The latter are commonest in connexion with bone-disease, and then frequently affect both surfaces of the membrane.

In **syphilis** cellular infiltrations and granulations are formed in the dura mater, and lead in time to dense scar-like thickenings, which frequently enclose caseous masses. If the process goes on extensive adhesions are set up with the arachnoid and pia mater.

Most **tumours** of the dura mater are sarcomatous. The spindle-celled forms are the most frequent, but round-celled and multiform-celled types are also found. We also meet with **alveolar sarcomata** and **endotheliomata**, characterised by the formation of cell-nests and reticulated strings of cells (Fig. 284 *cd*) within a fibrous stroma (*a*). These latter take the form of flattened or pedunculated fungoid outgrowths (*fungus durae matris*), varying from the size of a pea to that of an apple, which grow inwards and indent the surface of the brain or cord. On the outer aspect of the dura they erode and even perforate the bone by continuous pressure and consequent atrophy. They are commonest within the cranium, being indeed rare in the spinal canal. The pedicle sends out root-like processes of cells into the substance of the dura mater, from which the growth evidently originates. The endothelium of the lymphatic vessels furnishes the characteristic clusters and strings of cells, and the latter are often excavated (*d*) in a way that immediately suggests the parent vessel. This appearance is visible chiefly in the recent parts of the growth,

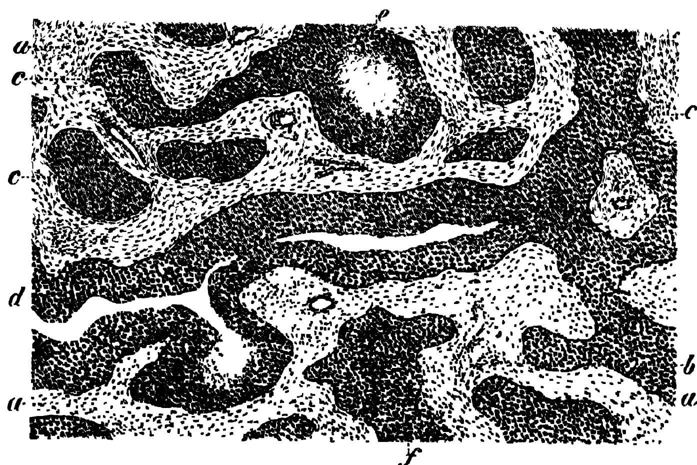


FIG. 284. ENDOTHELIOMA OF THE DURA MATER.

(*Hardened in Müller's fluid, stained with haematoxylin, and mounted in Canada balsam*: ×25)

fibrous stroma
group of round-cells
nests and strings of cells derived from the endothelium of the lymphatic vessels

d tubular tract of endothelial cells
e fatty degeneration of a cellular mass
f mass of endothelial cells, on the right side passing gradually into the fibrous stroma

the older parts showing merely a diffuse cell-growth which passes gradually into the structure of the fibrous tissue. When tumours of the dura mater become very vascular they may assume some of the characters of **angioma**; if the vessels calcify and give rise to an abundant production of brain-sand the growth becomes a **psammoma**.

Fibroma is on the whole rare, but it may occur in any part of the dura mater, forming rounded tumours; **lipoma** is very rare.

Enchondroma is not infrequently met with in the form of small gelatinous nodules about the back of the sella turcica and basilar portion of the occipital bone; the tumour originates in residual unossified fragments of the cartilaginous synchondrosis between this bone and the sphenoid.

Osteoma occurs chiefly in the cerebral dura mater, and most frequently about the falx cerebri. The growth appears as a plate of bone of irregular form with spinous and ridge-like processes.

Of secondary or **metastatic growths** in the dura mater carcinoma is the most usual.

References on pachymeningitis:—VIRCHOW, *Würzburg. Verhandl.* 1856; SCHUBERG, *Virch. Arch.* vol. 16; KREMIANSKY, *ibid.* vol. 42; WEBER, *Arch. d. Heilk.* I 1860 (haematoma); LANCEREAUX, *Arch. générales de méd.* 1862—63, *Traité d'anat. path* II; WILKS, *Med. Times and Gaz.* 1, 1868; RINDFLEISCH, *Path. Hist.* II London 1873; SPERLING, *Cent. f. med. Wiss.* 29, 1871; PAULUS, *Verkalkung und Verknocherung d. Hamatomes d. Dura Mater* Erlangen 1875; HUGUENIN, *Ziemssen's Cyclop.* XII.

On tumours of the dura mater:—ROKITANSKY, *Lehrb. d. path. Anat.* II; ROBIN, *Recherches anat. sur l'epithéliome des séreuses, Journ. de l'anat.* 1869; LEBERT, *Virch. Arch.* vol. 3; ARNOLD, *ibid.* vol. 52; RUSTIZKY, *ibid.* vol. 52; BIZZOZERO and BOZZOLO, *Wiener med. Jahrb.* 1874; SCHUPPEL, *Arch. d. Heilk.* X (1869); VIRCHOW, *Die Entwickelung d. Schädelgrundes* 1857 (ecchondrosis of the basi-occipital); LUSCHKA, *Virch. Arch.* vol. 11 (ditto); ZENKER, *ibid.* vol. 12 (ditto); LANCEREAUX, *Traité d'anat. path.* II.

665. The hypophysis cerebri or **pituitary body** is seated in the sella turcica, and is composed of two lobes: the anterior consists of a fibrous stroma enclosing numerous round and oval follicles filled with epithelial cells, the posterior of vascular connective tissue containing cell-like clusters of fat-granules. At the junction of the two lobes the tissue is very vascular, and contains cavities lined with ciliated columnar epithelium (WEICHSELBAUM).

Cystic degeneration and hyperplastic overgrowth of the anterior lobe are not uncommon, the cysts usually containing colloid masses. This transformation is called **adenoma** of the pituitary body (WEIGERT), and the growth sometimes reaches the size of a hen's egg. It of course protrudes more or less from the sella turcica, presses on the adjoining brain-substance, or into the ventricles (ZENKER), and sometimes leads to atrophy of the underlying bone.

According to WEICHSELBAUM the ciliated cavities are very apt to undergo cystic change, the cysts containing homogeneous or granular matter secreted by the epithelium.

After adenoma the commonest growths are **carcinoma** and **sarcoma** (KLEBS), which also take the form of nodose swellings. WEICHSELBAUM has described a pair of small lipomata in the posterior lobe, and WEIGERT a teratoma.

The pituitary body may be inflamed in connexion with disease

of the neighbouring parts: tubercles and gummata are however rare in this situation (WEIGERT).

The **pineal body** consists of fibrous tissue enclosing a number of more or less spherical follicles, each containing a reticulate structure of epithelial cells, a number of rounded cells with slender processes (TOLDT), and a quantity of brain-sand.

The most frequent pathological changes observed in this organ are—abnormal increase of the quantity of brain-sand (psammoma), hyperplastic enlargement (so-called glioma), and cystic degeneration (hydrops cysticus); it may participate in inflammations of the adjacent structures. The author once found in it a tumour as large as a pigeon's egg, consisting essentially of blood-clot (haematoma).

References on the pituitary body:—VIRCHOW, *Die krankhaften Geschwülste*; ZENKER, *Virch. Arch.* vol. 13; WAGNER, *Arch. d. Heilk.* 1862; WEIGERT, *Virch. Arch.* vol. 65; WEICHSELBAUM, *ibid.* vol. 75; RIBBERT, *ibid.* vol. 90; KLEBS, *Viertelj. f. prakt. Heilk.* 125; BECK, *Zeitschr. f. Heilk.* IV 1883 (teratoma); BERNHARDT, *Beitrage z. Sympt. u. Diagnostik d. Hirngeschwulste* Berlin 1881.

SECTION XII.

PERIPHERAL NERVOUS SYSTEM.

CHAPTER XCIX.

STRUCTURE OF PERIPHERAL NERVES.

666. The peripheral nervous system is composed of **nerves** and **ganglia**, together with certain **terminal organs**. The nerves consist essentially of medullated and non-medullated fibres: in the ganglia there are similar nerve-fibres and associated ganglion-cells.

A **medullated fibre** is a long cylindrical structure, the axis being occupied by the so-called **axis-cylinder**. During life the latter is homogeneous and enclosed in a sheath of myeline (**medullary sheath**), and this again in a delicate fibrous envelope—the primitive sheath, neurilemma, or **sheath of Schwann**. The medullary sheath is interrupted at intervals by the **nodes of Ranvier**: at these points the axis-cylinder is covered only by the sheath of Schwann, and chiefly through them is its nutrition kept up. Each nerve-fibre is thus subdivided into segments of 1 to 2 mm. in length; each segment has about its middle a nucleus lying close to the sheath of Schwann, and on the inner side of the sheath close to the nucleus is a thin layer of protoplasm. External *to the sheath of* Schwann is a fibrillar sheath (AXEL KEY and RETZIUS), which also contains nuclei and a scanty protoplasm.

The **non-medullated fibres** possess an axis-cylinder with a primitive sheath containing nuclei at intervals.

Both kinds of fibres unite to form nerves of various degrees of thickness: the nerves from the brain and cord consist chiefly of medullated fibres, those of the sympathetic system chiefly of non-medullated fibres.

The smaller nerves consist of a single bundle of nerve-fibres, the larger nerves of a certain number of bundles.

Each bundle (Figs. 286, 288 *c*) is surrounded by a fibrous envelope or **perineurium**: in a large trunk several such bundles are enclosed in a perineurium (Fig. 288 *a*), each of them being surrounded by an **epineurium** (*b*) of loose connective tissue, often containing fat-cells. Septa pass from the perineurium between the bundles (Fig. 286), and subdividing into finer fibres surround the individual nerve-fibres with an **endoneurium**. The blood-

vessels of the nerve-trunk run in these fibrous envelopes. At the peripheral ends the axis-cylinders break up into primitive fibrils, and these terminate in the various peripheral end-organs.

In the course of some of the nerves (especially of the sympathetic) are one or more clustered groups of ganglion-cells: when these are large enough to be easily visible they are called **ganglia.** The cells and fibres of such a ganglion lie in a fibrous stroma whose elements are in direct continuity with the fibrous structures of the corresponding nerve.

The **morbid changes** occurring in the nerves affect partly the nervous elements, partly the fibrous framework. In many respects the changes correspond to those affecting the central nervous system, but they also offer remarkable peculiarities of their own.

CHAPTER C.

ATROPHY AND DEGENERATION.

667. The degenerative processes which lead to **atrophy** and disappearance of the peripheral nerve-fibres and ganglion-cells correspond in their general course with the like processes in the brain and cord.

In the first place fibres and cells may gradually dwindle and waste away without undergoing *any appreciable change of structure.* More frequently however the destruction is speedier and accompanied with the various evidences of disintegration so often observed in the central organs.

In the **medullated fibres** there appears first a turbidity and then a splitting up of the medullary sheath, leading to the formation of large and then of smaller fragments and droplets of myeline, until the whole sheath is reduced to globules or particles. The axis-cylinder and its primitive fibrils may in like manner break up into small fragments (Fig. 285 *c*), or swell up and become liquefied; though it must be remembered that the axis shows itself more resistent towards many kinds of injury than the medullary sheath.

The sheath of Schwann usually remains intact, and even the so-called nerve-corpuscles or nuclei of the several segments persist also (Fig. 285 d d_1 d_2). When the medullary sheaths break up, extravasated leucocytes pick up the products of disintegration and form fat-granule cells which lie within the primitive sheaths or in the fibrous envelopes. Sometimes the cells of the connective tissue also become fatty.

The single or clustered ganglion-cells occurring in the course of the nerves perish by swelling and liquefaction, by fatty change, or by simple atrophy.

A medullated nerve which has lost its medullary sheath shrinks in volume and looks grey and translucent: if it is at the same time vascular its tint is greyish-red.

The exact manner and extent of the degeneration of the nerve-elements depends on the nature of the injurious or destructive agent which is at work; though in all degenerative processes there is one feature which is constant, namely the prompt extension of the change over all the portion of the nerve to the distal side of any point at which the axis-cylinder is completely interrupted.

Such an interruption is most quickly and most completely effected by **section of the nerve**, and thus in the investigation of peripheral degeneration such intentional or unintentional section plays the chief part. At the cut surfaces of a nerve there quickly appears a button-like protrusion and swelling of a grey or greyish-red tint, together with some gelatinous exudation. In a day or two the segments of the peripheral portion become less refractive, and turbid, and by the third day the medullary and primitive sheaths are deeply indented at the nodes. On the fourth to the sixth day the medulla breaks up into large drops of myeline, and in a few days more there is nothing of it left but droplets and granules of detritus which are ultimately absorbed.

The axis-cylinder speedily becomes almost or altogether invisible, and perishes partly by swelling and vacuolation, partly by breaking up into fragments.

In simple uncomplicated section of the nerve the proximal or central end degenerates for a small distance only from the wound, the change stopping at the first or second node of Ranvier. Only when the nerve-end is bruised or otherwise inflamed do some of the bundles degenerate for a greater distance. In such a case the primitive sheath of the degenerate fibres contains a large number of extravasated leucocytes, which in simple section are seldom or never very abundant.

Severe crushing or pinching and abiding compression (as from a tumour or a shrinking cicatrix) of a nerve have an effect similar to section, the latter leading to anaemic necrosis or degeneration of the compressed portion. The difference is chiefly in the fact that the interruption is not at once complete, but affects the several strands or bundles in succession.

Disease of the anterior horns of the cord and of the motor roots leading to destruction of motor ganglion-cells or nerve-fibres are, like other interruptions of the conducting tracts, followed by peripheral degeneration: but it must be kept in mind that when the destruction of the ganglion-cells is more gradual the corresponding atrophy of fibres is not so rapid, the medullary sheath wastes by degrees (Fig. 285 *b*), and within one and the same bundle we may find fibres that are sound, others partially atrophied (*b c*), and others totally destroyed (d_1 d_2).

A second frequent cause of degeneration of the nerves is primary and secondary **neuritis**, due to traumatic or infective inflammation of the connective-tissue framework (Art. 669), which leads to disturbance of the circulation and nutrition of the nerve or to direct compression of it. Sometimes too haemorrhages give rise to injurious pressure on the nerve-fibres.

Lastly, motor nerves atrophy when their **muscles** are long **disused** (FISCHER), the atrophy being however confined to the peripheral parts: there is no ascending atrophy of such nerves to any extent comparable with the descending atrophy.

Occasionally we meet with local or multiple peripheral degenerations of which we cannot with certainty discover the cause. Thus the **vagus** is subject to degenerative changes without any

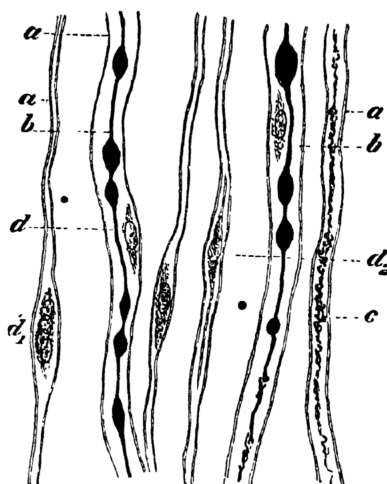


FIG. 285. ATROPHY OF MOTOR NERVES IN ANTERIOR POLIOMYELITIS.
(*Treated with Müller's fluid and perosmic acid, and teased out in glycerine:* × 200)

a sheath of Schwann
b axis-cylinder with adherent drops of myeline
c axis-cylinder breaking up
d uninuclear,
d_1 multinuclear,
d_2 bipolar cell within the sheath of Schwann

apparent compression, inflammation, or other injury. BLASCHKO describes a wide-spread fatty degeneration of Auerbach's and Meissner's plexuses in the intestines. The **multiple neuritis** of some authors (Art. 669) is in fact of the nature of degenerative atrophy.

In such isolated degenerations we must assume that some disorder of the circulation (due *e.g.* to change in the vessels or change in the blood) is at work. Thus **lead-poisoning** gives rise not only to degeneration of the muscular nerves (LANCEREAUX, GOMBAULT, FRIEDLÄNDER, etc.) but also to change in the intestinal plexuses. When the nerve-changes are acute and accompanied by febrile disturbance it is probable that infection of some kind is in question. R. MAIER showed experimentally that in chronic lead-poisoning the submucous and myenteric ganglion-cells become turbid, lose their nuclei, break into fragments, and disappear, while the connective tissue about them is simultaneously increased.

According to KEY, RETZIUS, S. MAYER, and KORYBUTT-DASZKIEWICZ, degenerative and regenerative changes take place normally in peripheral nerves; and many filaments hitherto assigned to the fibrous sheaths or the fibres of Remak are simply degenerate or nascent nerve-fibres.

The drops of myeline in degenerate nerves are stained black by perosmic acid, while the granular matters are unstained: S. MAYER infers from this that the nerve-substance breaks up into fatty and albuminoid component elements.

As to the exact fate of the axis-cylinder of the peripheral end of a cut nerve there is still some uncertainty, notwithstanding the numerous investigations that have been made: there is no question as to the medullary sheath. WALLER, EULENBURG, LANDOIS, HJELT, RANVIER, BENECKE, COSSY and DÉJÉRINE, TIZZONI, LEEGARD, VANLAIR, FALKENHEIM, and others state that the axis-cylinder degenerates; SCHIFF, PHILIPPEAU, KORYBUT-DASZKIEWICZ, ERB, CHARCOT, WOLBERG, and others maintain that it persists intact. In the text we have adopted the former account. After loss of the ganglion-cells in the anterior horns of the cord the axis-cylinders of the motor fibres, and after section of a peripheral nerve those of all the fibres, degenerate.

References on degeneration and regeneration of nerves after section:—WALLER, *Müller's Arch.* 1852, *Comptes rendus* 1851—52; SCHIFF, *ibid.* 1854; PHILIPPEAU and VULPIAN, *ibid.* 1859; HJELT, *Virch. Arch.* vol. 19; REMAK, *ibid.* vol. 23; EINSIEDEL, *Ueb. Nervenregener. nach Ausschneidung eines Nervenstückes* Giessen 1864; LAVERAN, *Rech. exp. sur la régénér. d. nerfs* Strasburg 1867; EULENBURG and LANDOIS, *Berl. klin. Woch.* 1864—65; ROBIN, *Journ. de l'anat.* 1868; NEUMANN, *Arch. d. Heilk.* IX (1868); ERB, *D. Arch. f. klin. Med.* IV, V; HERZ, *Virch. Arch.* vol. 46; VULPIAN, *Arch. de physiol.* 1873—74; WEIR-MITCHELL, *Injuries of nerves* London 1872; LÉTIÉVANT, *Traité des sections nerveuses* Paris 1873; LEEGARD, *D. Arch. f. klin. Med.* XXVI; BENECKE, *Virch. Arch.* vol. 55; RANVIER, *Leçons sur l'histologie du syst. nerv.* Paris 1878; COSSY and DÉJÉRINE, *Arch. de physiol.* 1875; ENGELMANN, *Pflüger's Arch.* XIII (1876); BAKOWIECKI, *Arch. f. mikrosk. Anat.* XIII (1876); COLOSANTI, *Arch. f. Anat. und Physiol.* 1878; GLUCK, *Virch. Arch.* vol 72, *Arch. f. klin. Chir.* XXV, XXVI; SANTI SIRENA, *Ricerce sperim. sulla reprod. d. nervi* Palermo 1880; TIZZONI, *Arch. p. l. sci. med.* III (1878), *Cent. f. med. Wiss.* 1878, *Sulla patolog. d. tessuto nervoso* Turin 1878; S. MAYER, *Degen. und Regen. d Nervenfasern* Prague 1881; HOGGAN, *Trans. Path. Soc.* XXXI (1880), *Journ. de l'anat.* XVIII (1882); GESSLER, *D. Arch. f. klin. Med.* XXXIII (motor-nerve changes after section), *Die motor. Endplatte u. ihre Bedeut. f. d. periphere Lähmung* Leipzig 1885; NEUMANN, *Arch. f. mikrosk. Anat.* XIII (1880), XVIII (1885); VANLAIR, *Arch. de biol.* III (1882); EICHHORST, *Eulenburg's Realencyclop. d. gesam. Heilkunde*, *Virch. Arch.* vol. 59; PEYERANI, *Biol. Centralb.* III (1883); FALKENHEIM, *Zur Lehre von d. Nervennaht* In. Diss. Konigsberg 1881; TILLMANNS, *Arch. f. klin. Chir.* XXVII; BASCH, *ibid.*; WOLBERG, *Deut. Zeitschr. f. Chir.* XVIII, XIX (1883); NICAISE, *Internat. encyclop. of surgery* III London 1883; P. BRUNS, *Mitth. a. d. chir. Klinik* II Tübingen 1884; CATTANI, *Arch. p. l. sci. med.* VIII 1885 (nerve-stretching); HAYEM and GILBERT, *Modification du syst. nerv. chez un amputé*, *Arch. de physiol.* III (1884).

The memoirs of VANLAIR, FALKENHEIM, TILLMANNS, and WOLBERG include not only experimental researches of their own, but also summaries of published cases, and criticisms on previous methods of experiment: the subject of nerve-suture is also dealt with. WOLBERG'S paper is the most comprehensive on all points bearing on the main subject.

On nerve-degeneration from lead-poisoning and from undetermined causes:—LANCEREAUX, *Gaz. méd. de Paris* 1862, 1871; GOMBAULT, *Arch. de physiol.* V (1873); DÉJÉRINE, *Gaz. méd. de Paris* 1879; ZENKER, *Zeitschr. f. klin. Med.* I (1880); WESTPHAL, *Arch. f. Psych.* IV (1873), VI (1875); REMAK, *ibid.* VI (1875); VULPIAN, *Mal. du syst. nerveux* Paris 1879; FRIEDLÄNDER, *Virch. Arch.* vol. 75; POPOW, *ibid.* vol. 93; R. MAIER, *ibid.* vol. 90; KUSSMAUL and MAIER, *D. Arch. f. klin. Med.* IX (1872); EISENLOHR, *ibid.* XXVI; BLASCHKO, *Virch. Arch.* vol. 94; DUMÉNIL, *Gaz. hebdom.* 1864; SCHULTZE, *Arch. f. Psych.* XIV; MONAKOW, *ibid.* X; MORITZ, *Journ. of Anat. and Physiol.* 1880; BIRDSALL, *Amer. Journ. of neurology* 1882; NAUNYN, *Ziemssen's Cyclop.* XVII.

On atrophy from disuse:—FISCHER, *Deut. Zeitschr. f. Chir.* VIII (1877); SIEGMUND MAYER, *Prag. med. Woch.* 1878.

CHAPTER CI.

REGENERATION OF NERVES.

668. **Union of severed nerves.** It has long been known that nerves which have been cut through, and whose function has been thereby completely abolished, are capable of repair, and in the course of weeks or months recover their conducting power. Recent surgery has utilised this fact, and seeks to bring about the speedier union and recovery of severed nerves by **suture** of their ends. Over fifty cases have already been published in which nerve-suture has resulted in more or less perfect restoration of function, and that not only when the wounds were recent but in some cases where suture did not take place till after the lapse of months or years from the time of injury.

The union and recovery of severed nerves has been often observed in animals as well as in men, and in recent years a large number of experiments have been made to throw light on the fact and on the histological process by which it is brought about. Unfortunately we do not yet fully understand all the steps of this process: opinions differ as to the fate of the peripheral end of a severed nerve (Art. 667), and it is therefore scarcely surprising that authorities are not agreed as to the details of **regeneration.** Hardly two of the multitude of writers on the subject take exactly the same view, and we are therefore unable to give an account of it which shall be wholly satisfactory.

When the functional continuity of a nerve is interrupted by section, crushing, compression, etc. various things may happen. The nerve-fibres only may be injured, the nerve remaining still macroscopically continuous; or it may be completely severed, the ends retracting some small distance apart, or becoming so widely separated that there is no possibility of their reuniting naturally. The regenerative process can be best followed in the second case, which is that most frequently observed experimentally, the parted nerve-ends being reunited by the intercalation of a new-formed piece of nerve.

The wound that severs a nerve is immediately followed by an inflammation, which leads to swelling of the cut ends, and the deposit of exudation between them. In the subsequent week or two granulations and cicatricial tissue are formed, while the central and peripheral ends undergo the changes referred to in Art. 667.

The regeneration of the nerve-fibres begins a few days after the operation (RANVIER) in the central end: RANVIER says at the very extremity of this end, VANLAIR at a distance of 1·5 to 2 cm. from it. EICHHORST observed the beginning of regeneration in the nerve of a rabbit on the fourteenth day after injury.

The first change is a swelling of some of the axis-cylinders in the outer parts (VANLAIR) of the nerve-bundles of the central end, and this is followed by subdivision of each into from two to five new axis-cylinders (RANVIER). The new cylinders grow in length, and form within the old sheath of Schwann whole bundles of new nerve-fibres (Fig. 286 *e*), which usually distend the lumen of the sheath and compress any persisting remnants of the older fibres (*f*). According to VANLAIR they sometimes burst the old sheath, and then either grow out amid the tissue of the endoneurium, or penetrate the perineurium of the bundles into the epineurium.

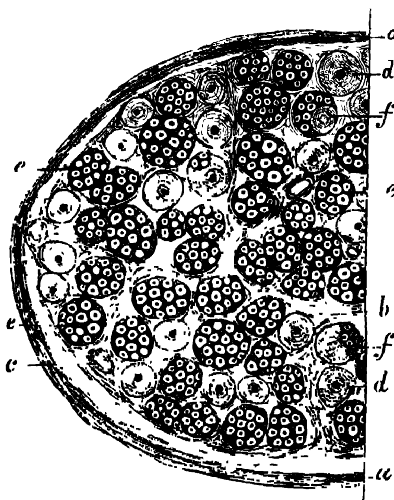


FIG. 286. CENTRAL END OF A NERVE-BUNDLE IN PROCESS OF REGENERATION.

(From the median nerve 4 months after severance by a stab: hardened in Müller's fluid, stained with neutral carmine, and mounted in Canada balsam: × 200)

a perineurium
b endoneurium
c blood-vessel
d old unaltered nerve-fibre
e bundle of new-formed nerve-fibres
f new-formed nerve-fibres compressing an old fibre within the same sheath

In this way at the extremity of the central end a large number of new fibres are developed. They consist at first of new-formed axis-cylinders surrounded by a protoplasmic nucleated sheath (VANLAIR), and presently they receive a homogeneous envelope of connective-tissue (*e*) formed at the expense of the protoplasmic sheath, and a thin medullary sheath which grows between the latter and the axis-cylinder. The perineurium of the bundles giving way and the new fibres thus dispersing as it were in the epineurium, the characteristic grouping of the nerve-fibres in

bundles is lost; the new fibres are more uniformly spread through the connective tissue, and the usually fatty epineural envelope assumes a striated fibrous appearance.

In this manner the re-formed and growing nerve enters the soft mass of granulations and cicatricial tissue that intervenes between the severed ends. When it reaches the peripheral end, some of whose fibres have meanwhile perished, certain of the new fibres enter the empty primitive sheaths (RANVIER), but the greater number penetrate the epineurium (VANLAIR) and perineurium and advance towards the peripheral end-organs. Others miss the peripheral end and run either alongside it or on a course of their own to the surface: many fibres too which leave the old track disappear and are lost in the tissues (VANLAIR). In the peripheral half of the intercalated cicatrix the nerve-fibres begin to gather once more into bundles (VANLAIR), and a perineurium forming round these, the whole thickness of the nerve by degrees assumes a nearly normal appearance.

These changes require weeks or months to complete: according to EICHHORST the fibres of the central end reach the cicatrix about the end of the first month, and in some three months the reunion is established.

It appears from the foregoing that the peripheral end does not itself regenerate, but is provided with nerve-fibres from the central end. VANLAIR describes the process as **neurotisation**. It probably takes place in all cases of regeneration after severance, both when the nerve is actually cut through and when only the nerve-fibres and not the fibrous structures are interrupted. The difference is that in the former case the new fibres must grow through a certain amount of cicatricial tissue, while in the latter there is little or no granulation, and the axis-cylinders as they lengthen can directly enter the old fibres. Some authorities (GLUCK, WOLBERG, LANGENFELDT) state definitely that under favourable conditions very rapid union of the severed ends is possible, the function of the nerve being recovered in a very few days.

Even when the peripheral is so remote from the central end that direct union by nerve-tissue is out of the question, some attempt is still made at regeneration. The central end grows out (Fig. 286), but the axis-cylinders do not reach the peripheral end, and lose themselves in the cicatrix.

The so-called **amputational neuromata** (Art. 154) are of this nature; they are club-shaped enlargements of the severed nerve-ends occasionally met with in stumps which have healed after amputation. As they contain new nerve-fibres as well as connective tissue they are doubtless due to an abortive attempt at regeneration in the nerve-stumps: when they include sensory fibres which are compressed or irritated by the cicatrix they are the source of very considerable pain. Similar traumatic neuromata now and then occur in the course of nerves which have been injured but not severed.

The statements of authors concerning the new-formation of the axis-cylinder in divided nerves are very discordant. WALLER, SCHIFF, RINDFLEISCH, CORNIL, RANVIER, EICHHORST, and others assert that it is due to longitudinal subdivision and growth in length of the old axis-cylinders. PHILIPPEAU, VULPIAN, REMAK, LEEGARD, NEUMANN, DOBBERT, DASZKIEWICZ, and others regard the new cylinder as derived from the peripheral end; LEEGARD believing that it arises from the nuclei of the neurilemma, REMAK from the uninjured and surviving cylinders, DASZKIEWICZ from the surviving segments of the old and partially degenerate cylinders, NEUMANN and DOBBERT from a protoplasmic mass produced by a chemical transformation of the medullary sheath and axis-cylinder. NASSE, GÜNTHER, SCHON and STEINRÜCK assert that the new cylinders grow from the old fibres of both ends: LEUT, EINSIEDEL, WEIR-MITCHELL, BENECKE, and GLUCK, from the primitive sheaths of both ends; LAVERAN and HERZ refer their origin to the white blood-cells, HJELT and WOLBERG to the cells of the perineurium.

As the text shows we incline to the view of those who derive the new nerve-fibres from the old nerves of the central end. The subdivision of the axis-cylinder is the essential part of the process, though it is perhaps not impossible that a new-formation of nerve-fibres may start from the cells or nerve-corpuscles or nuclei on the sides of the sheaths of Schwann. At any rate it is remarkable how frequently in degenerating nerves we find these cells (Fig. 285 dd_1) swollen up and containing several nuclei: sometimes indeed they give off processes which much resemble axis-cylinders (d_2). Until we have more information on the subject however it is more probable that these cells form merely the sheaths for the new axis-cylinders CATTANI asserts that new axis-cylinders are formed within the nucleated protoplasmic mass which he has observed filling the primitive sheath of degenerating nerves.

The hypothesis that nerve-fibres may grow from granulation-cells or from the connective-tissue cells of the perineurium, endoneurium, or epineurium, is contrary to all histogenetic analogy. The nerves throughout their length are originally outgrowths from the central nervous system (BALFOUR, HENSEN, HIS, KÖLLIKER, etc.), and it is extremely unlikely that in later life they can arise from indifferent connective-tissue cells: this would be at variance with all our experience on the subject of the regeneration of specific tissues. The authors who have made the assertion do not advance any convincing arguments in its favour.

Those who believe that after section of a nerve the axis-cylinders of the peripheral end remain intact assume that the ends of the severed cylinders reunite by the intercalation of a new piece of tissue. WOLBERG describes this as taking place by the growth of strings of spindle-cells from the epineurium. When the reunion does not take place till the medullary sheath disintegrates he speaks of the process as regeneration in the strict sense of the term. If reunion takes place before the sheath disappears he speaks of it as union by first intention, and distinguishes a mediate and an immediate variety. In the former the union is brought about by means of new-formed intercalary fibres, in the latter by direct adhesion of the severed ends of the cylinders and primitive sheaths. The existence of the mediate variety he claims to have experimentally proved. Such a union by first intention is very doubtful: GLUCK'S and WOLBERG'S experiments do not appear to prove it, and it is probable that mistakes have arisen from the rapid restoration of function that sometimes takes place by means of abnormal nervous anastomoses and supplementary fibres. The secondary or mediate union by means of intercalary fibres appears impossible, the cylinders of the peripheral end being already degenerate: and for the same reason the statements of GLUCK and others that a piece of nerve cut from one animal may become united to the two ends of a severed nerve in another must be regarded as resting on error.

CHAPTER CII.

INFLAMMATION OF PERIPHERAL NERVES AND GANGLIA.

669. **Neuritis**, or the inflammation of nerves, is characterised anatomically by the presence of an exudation in their fibrous framework. If the exudation is chiefly liquid and the blood-vessels are still filled, the inflamed nerve looks red, and swollen, and abnormally moist: if the exudation is cellular (Fig. 287) and the hyperaemia has disappeared there are no apparent signs of the affection, though any haemorrhage that has taken place may be indicated by reddish or brownish-yellow discoloration.

In simple nerves the migrated leucocytes lie chiefly in the thicker trabeculae of the endoneurium (Fig. 287 *d*) through which the vessels run, though they may also pass in between the individual nerve-fibres (*c e*).

In compound nerves (Fig. 288) the exudation frequently lies almost entirely in the epineurium. The perineurium of the

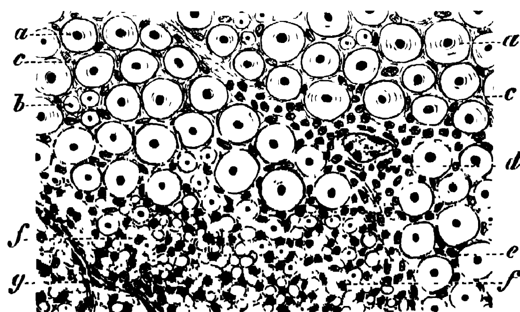


FIG. 287. CHRONIC NEURITIS.

(*Hardened in Müller's fluid and alcohol, stained with haematoxylin and carmine, and mounted in Canada balsam:* × 150)

a normal thick nerve-fibre
b normal fine nerve-fibre
c endoneurium
d blood-vessel, and trabeculae of endoneurium infiltrated with leucocytes
e leucocytes between the nerve-fibres
f thickened endoneurium with small spaces devoid of nerve-fibres and a few thin fibres still persisting
g longitudinal section of a blood-vessel

bundles and of the nerve generally is usually much less densely infiltrated.

Slight inflammations resolve without leaving any trace: severer attacks result in degeneration of some of the nerve-fibres. If the inflammation is suppurative or gangrenous the nerve rapidly breaks down and perishes, becoming of a dirty yellowish-white, grey, or greyish-green. The connective-tissue elements are however less vulnerable and long resist dissolution.

If the affection is chronic, degeneration of the nerve-fibres ultimately sets in, with the breaking up of some of the medullary sheaths. The axis-cylinders persist for a long time, though they too at length perish; and thus a certain number of the fibres disappear outright, the sheaths of Schwann collapsing (*f*). Wherever an axis-cylinder decays degeneration takes place all down the peripheral portion of that fibre (Art. 667). As the medullary sheaths break down the tissue of the nerve is beset with drops of myeline and granule-carrying cells.

In process of time the chronic inflammation leads to thickening and condensation of the connective tissue, and this with the atrophy of the nerve-elements gives the nerve by degrees the appearance of a fibrous cord. Whether the nerve as a whole is thicker or thinner than in health depends on the proportion between the fibrous hyperplasia and the nervous atrophy. Both in simple and in compound nerves the inflammation may and sometimes does extend over the whole cross-section. In compound nerves the separation of the bundles becomes less distinct, though it is not obliterated even when the atrophy and fibrous changes are very advanced. When the process has been accompanied by haemorrhage the altered tissue is frequently pigmented.

Chronic neuritis accompanied by great fibrous hyperplasia has been called by VIRCHOW **proliferous neuritis**: if it extends upwards or downwards we speak of it as ascending or descending neuritis respectively.

One of the commonest causes of neuritis is mechanical injury (cutting, bruising, etc.) by a wound or blow: the inflammation results in fibrous hyperplasia, but if it becomes septic suppuration or gangrene may set in.

Moreover the inflammatory process sometimes extends to a nerve from the adjacent tissues; thus nerves running through a wound may undergo granulation or even suppuration without having received any direct injury, and the like extension takes place in the case of other inflammations.

For example, it is extremely common for cerebrospinal nerves traversing an inflamed meninges to be themselves invaded by the inflammatory infiltration. And inflammations of the bones lead to indirect degeneration by compression or to direct inflammation of the nerves that traverse them. This also happens to nerves lying in the neighbourhood of chronically inflamed or tuberculous

lymphatic glands. It is not uncommon for instance for caseous glands in the neck, beside the trachea, or at the root of the lung, to press upon contiguous nerves, like the vagus and its branches, to irritate them into inflammation, and so to bring about their degeneration. In the pelvis inflammations of the bladder or of the internal generative organs are apt to extend to the cellular connective tissue and so to the rich nerve-plexuses of that region.

These forms of neuritis are consecutive or secondary, but other forms occur in which the irritant inducing the inflammation is brought to the nerve directly by way of the blood or lymph. These irritants are so far as we know chiefly of an infective nature: thus in typhus (BERNHARDT), small-pox (JOFFROY), typhoid (NOTHNAGEL, LEYDEN, EISENLOHR), and diphtheria (OERTEL, CHARCOT, BUHL, DÉJÉRINE) we meet with simple or multiple neuritis, which we can only regard as direct results of the general infection.

Recently BAELZ and SCHEUBE have shown that the epidemic disease of India and Japan known as **beriberi** or **kakke** is characterised by the appearance of multiple neuritis: it has therefore been designated (BAELZ) as **panneuritis epidemica**.

It does not appear that there is any affection in Europe exactly corresponding to the Japanese *kakke,* but a form of multiple neuritis (LEYDEN) has more than once been described under the names of polyneuritis (PIERSON) and neuritis disseminata (ROTH). Whether this has any analogy to the infective disease, as PIERSON suspects, is still a very open question. Cold is spoken of by many as a cause of multiple neuritis, but probably in most cases some kind of infection or poison is at work. ROTH has shown that a purulent inflammation (as in parotitis) which involves a nerve-trunk may be the starting point of multiple neuritis.

Tuberculous and syphilitic inflammation affect chiefly the intracranial portions of cranial nerves and the spinal nerve-roots in connexion with meningeal tuberculosis and syphilis respectively.

Little is known of tuberculosis or syphilis of the peripheral nerves. Foci of some size are most frequently observed in the optic nerve, and give rise to extensive tuberculous destruction. Elsewhere nerves are seldom involved except by extension of tuberculous inflammation from diseased glands.

Leprous inflammation is especially apt to attack the nerves, the disease being in fact chiefly characterised by its thus involving the peripheral nervous system: a particular form of leprosy is distinguished as *lepra nervorum anaesthetica,* or *lepra mutilans* (Arts. 151, 206, 392, 659, and HOGGAN, *Arch. de physiol.* 1882). The settlement of the lepra-bacilli excites an intense inflammation, accompanied by cellular infiltration and followed by degeneration of the nerve-fibres and hyperplasia of the fibrous tissue. Fusiform thickenings and tuberosities of considerable firmness and size are thus produced in the course of the several nerves. The diseased

tissue contains lepra-bacilli, some lying free and others being enclosed in cells.

We know little concerning the **inflammations of the ganglia**: they apparently occur under the same conditions as those of the nerves, and like them they are characterised by cellular infiltration, fibrous hyperplasia, and degenerative atrophy of the nerve-elements.

In severe cystitis and pyelonephritis and in inflammation of the internal generative organs in women paralysis of the lower limbs is sometimes a symptom. REMAK (*Med. Central-Zeitung* 1860) and LEYDEN (*Sammlung klin. Vortrage* 2, 1870) explain this as due to a progressive or wandering neuritis, which has been called **neuritis disseminata migrans** (LEYDEN). The experimental researches of WEIR-MITCHELL (*Injuries of nerves* London 1872), TIESLER (*Ueb. Neuritis* In. Diss. Königsberg 1869), FEINBERG (*Berl. klin. Woch.* 1871), KLEMM (*Ueb. Neuritis migrans* In. Diss. Strasburg 1874), NIEDICK (*Arch. f. exp. Path.* VII 1877), ROSENBACH (*ibid.* VIII), and TREUB (*ibid.* X) fail to confirm this explanation. It is much more likely that in the affections named the pelvic plexuses are compressed or directly inflamed by extension from the inflammation of the cellular connective tissue (pelvic cellulitis). See discussion by ADAMS and others (*Lancet* 2, 1880).

On multiple neuritis :—DUMÉNIL, *Gaz. hebdom.* 1864, 1866 ; LEYDEN, *Ueb. Reflexlähmung, Samml. klin. Vortrage* 2, 1870, *Charité-Annalen* V, *Arch. f. Psych.* VI, *Zeitschr. f. klin. Med.* I 1880 ; CASPARI, *ibid.* V ; GRAINGER STEWART, *Edin. Med. Journ.* 1881 ; EICHHORST, *Virch. Arch.* vol. 69 ; JOFFROY, *Arch. de physiol.* 1879 ; EISENLOHR, *D. Arch. f. klin. Med.* XXVI ; MARCHAND, *Virch. Arch.* vol. 81 ; ERB, *Ziemssen's Cyclop.* XIII ; NOTHNAGEL, *Samml. klin. Vortrage* 103, trans. New Syd. Soc. London 1877 ; PIERSON, *Ueb. Polyneuritis acuta, ibid.* 229 ; GEPPERT, *Multiple Neuritis, Charité-Annalen* 1883 ; STRÜMPELL, *Arch. f. Psych.* XIV (*Neurolog. Centralb.* 1884) ; MULLER, *ibid.* ; VIERORDT, *ibid.* ; ROTH, *Neuritis dissem. acutissima, Corresp. f. Schweizer Aerzte* 1883 ; DUBOIS, *Multiple Neuritis, ibid.* ; BAELZ, *Kakke oder Beriberi* Yokohama 1882, *Zeitschr. f. klin. Med.* IV 1882 ; SCHEUBE, *Virch. Arch.* vol. 95, *D. Arch. f. klin. Med.* XXXI, XXXII, *Die japanische Kakke* Leipzig 1882 ; HIRSCH, *Handb. d. hist. geog. Path.* (2nd edition), trans. by CREIGHTON (New Syd. Soc.) II London 1885 (beriberi, with full references) ; CASPARI, *Zeitschr. f. klin. Med.* 1883 ; DÉJÉRINE, *Arch. de physiol.* 1884 ; WEBBER, *Archives of medicine* 1884 ; OPPENHEIM, *D. Arch. f. klin. Med.* XXXVI 1885 ; BUZZARD, *Paralysis from peripheral neuritis* London 1886.

On neuritis in infective diseases :—BERNHARDT, *Arch. f. Psych.* IV ; JOFFROY, *loc. cit.* ; NOTHNAGEL, *D. Arch. f. klin. Med.* IX (1872) ; EISENLOHR, *Arch. f. Psych.* VI ; CORMACK, *Clinical studies* London 1876 ; MURCHISON, *Continued fevers* London 1884 ; CHARCOT, *Diseases of the nervous system* II London 1880 ; BUHL, *Zeitschr. f. Biol.* III ; OERTEL, *D. Arch. f. klin. Med.* VIII ; DÉJÉRINE, *Arch. d. physiol.* V 1878 ; BUZZARD, *Lancet* 1, 1879, and *op. cit.* ; PITRES and VAILLARD, *Rev. de médecine* 1885 ; ROSS, *Diseases of the nervous system* II London 1883 (with many references) ; P. KIDD, *Med. chir. Trans.* LXVI 1883 (diphtherial paralysis).

On neuritis in herpes zoster see Art. 383 ; DUBLER, *Neuritis bei Herpes zoster* In. Diss. Basle 1884.

CHAPTER CIII.

TUMOURS.

670. Most of the **tumours** which occur in the nerves and their ganglia are developed from connective tissue, and consist essentially of some modification of that tissue, the nerve-elements forming little or no part of their structure.

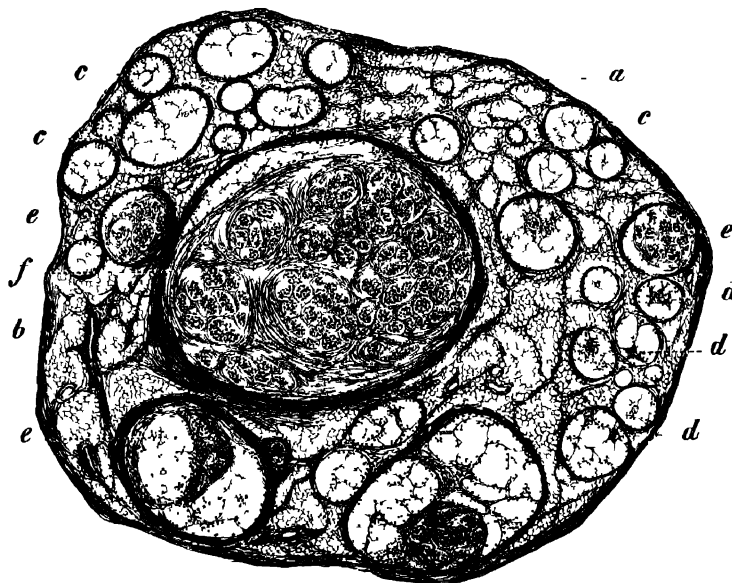


FIG. 288. MULTIPLE FIBROMA OF A NERVE OF THE SCIATIC PLEXUS.

(*Hardened in Muller's fluid, stained with carmine, and mounted in Canada balsam.* × 10)

a general perineurium
b epineurium containing numerous fat-cells
c nerve-bundle enclosed in a special perineurium
d commencing fibroma in the endoneurium
e more advanced fibroma within a nerve-bundle containing atrophied fibres
f large fibroma-nodule within a bundle whose perineurium is thickened

The fibrous hyperplasia usually starts from the perineurium of the nerves or nerve-bundles, but occasionally from the epineurium or endoneurium (Fig. 288 *d e f*). The nerves are embedded or

pervaded by the new tissue, according to its starting-point, and by gradual compression become atrophied and break down. If there is any accompanying nervous hyperplasia it probably takes place by the longitudinal subdivision and growth of pre-existing fibres: the new-formed fibres are at first naked, but some of them receive a medullary sheath in course of time.

The commonest neoplasm affecting the nerves is **fibroma** (Fig. 288): there are two forms—the soft and cellular, and the firm and fibrous. Tumours really deserving the name of **neuroma**, *i. e.* consisting essentially of new-formed nerve-fibres, are rare; and still rarer, if they exist at all, are tumours containing new-formed ganglion-cells, though these are described under the name of cellular or **ganglionic neuroma**.

Fibromata incorrectly described as neuromata are solitary or multiple, and in the latter case are congenital or at least appear soon after birth. Obviously the foundation of these structures is laid during foetal life; sometimes their heredity can be demonstrated. They occur in nerve-trunks and on their finest twigs and branches, forming fusiform, nodular, or very elongated thickenings of the nerve or nerves. Sometimes a nerve is found thickened over its whole extent, with perhaps occasional fusiform swellings.

The spinal nerves are the most frequent seat of these growths, though they also occur on the cranial nerves. Sometimes all the nerves are simultaneously affected, even the finest branches showing thickenings and knotty swellings. Thus all the branches of the vagus in the lungs and stomach, or those of the sympathetic in the liver, have been described as covered with fibromata, but these cases are very rare. Not infrequently however we find the smaller cutaneous nerves beset with small round or flat usually soft tumours, some being buried in the skin, others protruding. These growths are known as **fibroma molluscum** (VON RECKLINGHAUSEN, Art. 399). The cutaneous nodules are often in great numbers and extend over the territory of a particular nerve or over the whole body; they are sometimes accompanied by neurofibromata of the internal organs. Sometimes too between the nodules extensive hyperplasia of the subcutaneous and cutaneous fibrous tissue takes place, and large soft masses and folds are thus produced and known as **pachydermatocele**, elephantiastic molluscum, elephantiasis mollis or neuromatous elephantiasis (Art. 399). The smallest growths may only be visible with a lens, the largest are sometimes the size of a kidney or larger.

The fusiform or nodose thickening of a nerve is often due to a single tumour; but a nerve-trunk sometimes includes several nodules in its cross-section, some lying in all or most of its bundles (Fig. 288). A central node will give rise to a fibrous tumour surrounded by nerve-bundles and a perineurium: when the fibroma starts in one of the outside bundles it at length appears as if seated on the nerve-trunk.

At times most of the nodes are confined to a single nerve. Other nodes, and these occasionally very large, consist of a plexus of many nerves united into a mass by hyperplastic fibrous tissue. The nerves are all thickened, nodular, fusiform, convoluted, twisted, or otherwise distorted (Fig. 289), so that a coil of ravelled and



FIG. 289. PLEXIFORM NEUROFIBROMA OF THE SACRUM.
(*Natural size from a drawing by P. BRUNS*)
a convoluted strands laid bare by dissection
b as they appear covered with fibrous tissue

varicose cords is formed, the whole being held together by fibrous tissue. Such a growth is described as a **plexiform neurofibroma.** According to P. BRUNS the cords contain numerous nerve-fibres, and it is therefore probable that new-formed nerve-fibres as well as fibrous tissue take part in its construction.

Of the other connective-tissue growths sarcoma, myxoma, and lipoma occur in connexion with the nerves. The external forms they assume are similar to those of fibroma, but they are never multiple.

On neurofibroma:—VIRCHOW, *Krankhafte Geschwulste* III (1863); HITCHCOCK, *Amer. Journ. med. sci.* 1862; CZERNY, *Arch. f. klin. Chir.* XVII 1874; P. BRUNS, *Virch. Arch.* vol. 50; VON RECKLINGHAUSEN, *Ueb. mult. Fibrome d. Haut* Berlin 1882; KOBNER, *Virch. Arch.* vol. 93; LAHMANN, *ibid.* vol. 101; NICAISE, *Internat. ency. of surgery* III London 1883; PRUDDEN, *Amer. Journ. med. sci.* 1880 (with cases); COURVOISIER, *Die Neurome* Basle 1886 (with numerous references); CHAVASSE, *Med. chir. Trans.* LXIX 1886. Tumours (fibroma, fibrosarcoma neurofibroma) occur more frequently on the auditory than on other cranial nerves; see VIRCHOW (*op. cit.*), and AXEL KEY (*Sarskildt af Nordiskt med. Arkiv* XI 1879).

INDEX OF AUTHORS CITED

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(The numbers refer to the articles)

(The numbers refer to the articles.)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(The numbers refer to the articles)

INDEX OF SUBJECTS

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(The numbers refer to the articles)

(The numbers refer to the articles)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(The numbers refer to the articles)

(*The numbers refer to the articles*)

(*The numbers refer to the articles*)

CAMBRIDGE: PRINTED BY C. J. CLAY, M.A. AND SONS, AT THE UNIVERSITY PRESS